CHAPTER 1

Chemistry and Measurement

■ SOLUTIONS TO EXERCISES

Note on significant figures: If the final answer to a solution needs to be rounded off, it is given first with one nonsignificant figure, and the last significant figure is underlined. The final answer is then rounded to the correct number of significant figures. In multistep problems, intermediate answers are given with at least one nonsignificant figure; however, only the final answer has been rounded off.

1.1. From the law of conservation of mass,

Mass of wood + mass of air = mass of ash + mass of gases

Substituting, you obtain

1.85 grams + 9.45 grams = 0.28 grams + mass of gases

or,

Mass of gases = (1.85 + 9.45 − 0.28) grams = 11.02 grams

Thus, the mass of gases in the vessel at the end of the experiment is 11.02 grams.

1.2. Physical properties: soft, silvery-colored metal; melts at 64°C.
Chemical properties: reacts vigorously with water, with oxygen, and with chlorine.

1.3. a. The factor 9.1 has the fewest significant figures, so the answer should be reported to two significant figures.

$$\frac{5.61 \times 7.891}{9.1} = 4.\underline{8}6 = 4.9$$

b. The number with the least number of decimal places is 8.91. Therefore, round the answer to two decimal places.

$8.91 - 6.435 = 2.4\underline{7}5 = 2.48$

c. The number with the least number of decimal places is 6.81. Therefore, round the answer to two decimal places.

$6.81 - 6.730 = 0.0\underline{8}0 = 0.08$

d. You first do the subtraction within parentheses. In this step, the number with the least number of decimal places is 6.81, so the result of the subtraction has two decimal places. The least significant figure for this step is underlined.

$38.91 \times (6.81 - 6.730) = 38.91 \times 0.0\underline{8}0$

Next, perform the multiplication. In this step, the factor $0.0\underline{8}0$ has the fewest significant figures, so round the answer to one significant figure.

$38.91 \times 0.0\underline{8}0 = \underline{3}.11 = 3$

1.4. a. 1.84×10^{-9} m = 1.84 nm

b. 5.67×10^{-12} s = 5.67 ps

c. 7.85×10^{-3} g = 7.85 mg

d. 9.7×10^{3} m = 9.7 km

e. 0.000732 s = 0.732 ms, or 732 µs

f. 0.000000000154 m = 0.154 nm, or 154 pm

1.5. a. Substituting, we find that

$$t_C = \frac{5°C}{9°F} \times (t_F - 32°F) = \frac{5°C}{9°F} \times (102.5°F - 32°F) = 39.\underline{1}67°C$$

$$= 39.2°C$$

b. Substituting, we find that

$$T_K = \left(t_c \times \frac{1\ K}{1°C}\right) + 273.15\ K = \left(-78°C \times \frac{1\ K}{1°C}\right) + 273.15\ K = 19\underline{5}.15\ K$$

$$= 195\ K$$

1.6. Recall that density equals mass divided by volume. You substitute 159 g for the mass and 20.2 g/cm^3 for the volume.

$$d = \frac{m}{V} = \frac{159\ g}{20.2\ cm^3} = 7.8\underline{7}1\ g/cm^3 = 7.87\ g/cm^3$$

The density of the metal equals that of iron.

1.7. Rearrange the formula defining the density to obtain the volume.

$$V = \frac{m}{d}$$

Substitute 30.3 g for the mass and 0.789 g/cm^3 for the density.

$$V = \frac{30.3\ g}{0.789\ g/cm^3} = 38.\underline{4}0\ cm^3 = 38.4\ cm^3$$

1.8. Since one pm = 10^{-12} m, and the prefix milli- means 10^{-3}, you can write

$$121\ pm \times \frac{10^{-12}\ m}{1\ pm} \times \frac{1\ mm}{10^{-3}\ m} = 1.21 \times 10^{-7}\ mm$$

1.9. $$67.6\ Å^3 \times \left(\frac{10^{-10}\ m}{1\ Å}\right)^3 \times \left(\frac{1\ dm}{10^{-1}\ m}\right)^3 = 6.76 \times 10^{-26}\ dm^3$$

1.10. From the definitions, you obtain the following conversion factors:

$$1 = \frac{36\ in}{1\ yd} \qquad 1 = \frac{2.54\ cm}{1\ in} \qquad 1 = \frac{10^{-2}\ m}{1\ cm}$$

The conversion factor for yards to meters is as follows:

$$1.000 \text{ yd} \times \frac{36 \text{ in}}{1 \text{ yd}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{10^{-2} \text{ m}}{1 \text{ cm}} = 0.9144 \text{ m (exact)}$$

Finally,

$$3.5\underline{4} \text{ yd} \times \frac{0.9144 \text{ m}}{1 \text{ yd}} = 3.2\underline{3}7 \text{ m} = 3.24 \text{ m}$$

■ ANSWERS TO CONCEPT CHECKS

1.1. Box A contains a collection of identical units; therefore, it must represent an element. Box B contains a compound because a compound is the chemical combination of two or more elements (two elements in this case). Box C contains a mixture because it is made up of two different substances.

1.2. a. For a person who weighs less than 100 pounds, two significant figures are typically used, although one significant figure is possible (for example, 60 pounds). For a person who weighs 100 pounds or more, three significant figures are typically used to report the weight (given to the whole pound), although people often round to the nearest unit of 10, which may result in reporting the weight with two significant figures (for example, 170 pounds).

b. Assuming a weight of 165 pounds, rounded to two significant figures this would be reported as 1.7×10^2 pounds.

c. For example, 165 lb weighed on a scale that can measure in 100-lb increments would be 200 lb. Using the conversion factor 1 lb = 0.4536 kg, 165 lb is equivalent to 74.8 kg. Thus, on a scale that can measure in 50-kg increments, 165 lb would be 50 kg.

1.3. a. If your leg is approximately 32 inches long, this would be equivalent to 0.81 m, 8.1 dm, or 81 cm.

b. One story is approximately 10 feet, so three stories is 30 feet. This would be equivalent to approximately 9 m.

c. Normal body temperature is 98.6°F, or 37.0°C. Thus, if your body temperature were 39°C (102°F), you would feel as if you had a moderate fever.

d. Room temperature is approximately 72°F, or 22°C. Thus, if you were sitting in a room at 23°C (73°F), you would be comfortable in a short-sleeve shirt.

1.4. Gold is a very unreactive substance, so comparing physical properties is probably your best option. However, color is a physical property you cannot rely on in this case to get your answer.

One experiment you could perform is to determine the densities of the metal and the chunk of gold. You could measure the mass of the nugget on a balance and the volume of the nugget by water displacement. Using this information, you could calculate the density of the nugget. Repeat the experiment and calculations for the sample of gold. If the nugget is gold, the two densities should be equal and be 19.3 g/cm^3.

Also, you could determine the melting points of the metal and the chunk of pure gold. The two melting points should be the same (1338 K) if the metal is gold.

■ ANSWERS TO SELF-ASSESSMENT AND REVIEW QUESTIONS

1.1. One area of technology that chemistry has changed is the characteristics of materials. The liquid-crystal displays (LCDs) in devices such as watches, cell phones, computer monitors, and televisions are materials made of molecules designed by chemists. Electronics and communications have been transformed by the development of optical fibers to replace copper wires. In biology, chemistry has changed the way scientists view life. Biochemists have found that all forms of life share many of the same molecules and molecular processes.

1.2. An experiment is an observation of natural phenomena carried out in a controlled manner so that the results can be duplicated and rational conclusions obtained. A theory is a tested explanation of basic natural phenomena. They are related in that a theory is based on the results of many experiments and is fruitful in suggesting other, new experiments. Also, an experiment can disprove a theory but can never prove it absolutely. A hypothesis is a tentative explanation of some regularity of nature.

1.3. Rosenberg conducted controlled experiments and noted a basic relationship that could be stated as a hypothesis—that is, that certain platinum compounds inhibit cell division. This led him to do new experiments on the anticancer activity of these compounds.

1.4. Matter is the general term for the material things around us. It is whatever occupies space and can be perceived by our senses. Mass is the quantity of matter in a material. The difference between mass and weight is that mass remains the same wherever it is measured, but weight is proportional to the mass of the object divided by the square of the distance between the center of mass of the object and that of the earth.

1.5. The law of conservation of mass states that the total mass remains constant during a chemical change (chemical reaction). To demonstrate this law, place a sample of wood in a sealed vessel with air, and weigh it. Heat the vessel to burn the wood, and weigh the vessel after the experiment. The weight before the experiment and that after it should be the same.

1.6. Mercury metal, which is a liquid, reacts with oxygen gas to form solid mercury(II) oxide. The color changes from that of metallic mercury (silvery) to a color that varies from red to yellow depending on the particle size of the oxide.

1.7. Gases are easily compressible and fluid. Liquids are relatively incompressible and fluid. Solids are relatively incompressible and rigid.

1.8. An example of a substance is the element sodium. Among its physical properties: It is a solid, and it melts at 98°C. Among its chemical properties: It reacts vigorously with water, and it burns in chlorine gas to form sodium chloride.

1.9. An example of an element: sodium; of a compound: sodium chloride, or table salt; of a heterogeneous mixture: salt and sugar; of a homogeneous mixture: sodium chloride dissolved in water to form a solution.

1.10. A glass of bubbling carbonated beverage with ice cubes contains three phases: gas, liquid, and solid.

1.11. A compound may be decomposed by chemical reactions into elements. An element cannot be decomposed by any chemical reaction. Thus, a compound cannot also be an element in any case.

1.12. The precision refers to the closeness of the set of values obtained from identical measurements of a quantity. The number of digits reported for the value of a measured or calculated quantity (significant figures) indicates the precision of the value.

1.13. Multiplication and division rule: In performing the calculation 100.0 x 0.0634 ÷ 25.31, the calculator display shows 0.2504938. We would report the answer as 0.250 because the factor 0.0634 has the least number of significant figures (three).

Addition and subtraction rule: In performing the calculation 184.2 + 2.324, the calculator display shows 186.524. Because the quantity 184.2 has the least number of decimal places (one), the answer is reported as 186.5.

1.14. An exact number is a number that arises when you count items or sometimes when you define a unit. For example, a foot is defined to be 12 inches. A measured number is the result of a comparison of a physical quantity with a fixed standard of measurement. For example, a steel rod measures 9.12 centimeters, or 9.12 times the standard centimeter unit of measurement.

1.15. For a given unit, the SI system uses prefixes to obtain units of different sizes. Units for all other possible quantities are obtained by deriving them from any of the seven base units. You do this by using the base units in equations that define other physical quantities.

1.16. An absolute temperature scale is a scale in which the lowest temperature that can be attained theoretically is zero. Degrees Celsius and kelvins have units of equal size and are related by the formula

$$t_C = (T_K - 273.15\text{ K}) \times \frac{1°\text{C}}{1\text{ K}}$$

1.17. The density of an object is its mass per unit volume. Because the density is characteristic of a substance, it can be helpful in identifying it. Density can also be useful in determining whether a substance is pure. It also provides a useful relationship between mass and volume.

1.18. Units should be carried along because (1) the units for the answers will come out in the calculations, and (2), if you make an error in arranging factors in the calculation, this will become apparent because the final units will be nonsense.

1.19. The answer is c, three significant figures.

1.20. The answer is a, 4.43 x 10^2 mm.

1.21. The answer is e, 75 mL.

1.22. The answer is c, 0.23 mg.

■ ANSWERS TO CONCEPT EXPLORATIONS

1.23. a. First, check the physical appearance of each sample. Check the particles that make up each sample for consistency and hardness. Also, note any odor. Then perform on each sample some experiments to measure physical properties such as melting point, density, and solubility in water. Compare all of these results and see if they match.

b. It is easier to prove that the compounds were different by finding one physical property that is different, say different melting points. To prove the two compounds were the same would require showing that every physical property was the same.

c. Of the properties listed in part a, the melting point would be most convincing. It is not difficult to measure, and it is relatively accurate. The density of a powder is not as easy to determine as the melting point, and solubility is not reliable enough on its own.

d. No. Since neither solution reached a saturation point, there is not enough information to tell if there was a difference in behavior. Many white powders dissolve in water. Their chemical compositions are not the same.

1.24. Part 1

a. 3 g + 1.4 g + 3.3 g = $\underline{7}$.7 g = 8 g

b. First, 3 g + 1.4 g = $\underline{4}$.4 g = 4 g. Then, 4 g + 3.3 g = $\underline{7}$.3 g = 7 g.

c. Yes, the answer in part a is more accurate. When you round off intermediate steps, you accumulate small errors and your answer is not as accurate.

d. The answer 29 g is correct.

e. This answer is incorrect. It should be 3 x 10^1 with only one significant figure in the answer. The student probably applied the rule for addition (instead of for multiplication) after the first step.

f. The answer 28.5 g is correct.

g. Don't round off intermediate answers. Indicate the round-off position after each step by underlining the least significant digit.

Part 2

a. The calculated answer is incorrect. It should be 11 cm^3. The answer given has too many significant figures. There is also a small round off error due to using a rounded-off value for the density.

b. This is a better answer. It is reported with the correct number of significant figures (three). It can be improved by using all of the digits given for the density.

c. $$V = \frac{10 \text{ ball bearings}}{1} \times \frac{1.234 \text{ g}}{1 \text{ ball bearing}} \times \frac{1 \text{ cm}^3}{3.1569 \text{ g}} = 3.90\underline{8}89 = 3.909 \text{ cm}^3$$

d. There was no rounding off of intermediate steps; all the factors are as accurate as possible.

■ ANSWERS TO CONCEPTUAL PROBLEMS

1.25. a. Two phases: liquid and solid.

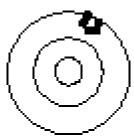
b. Three phases: liquid water, solid quartz, and solid seashells.

1.26. If the material is a pure compound, all samples should have the same melting point, the same color, and the same elemental composition. If it is a mixture, these properties should differ depending on the composition.

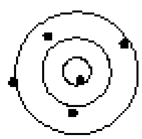
1.27. a. You need to establish two points on the thermometer with known (defined) temperatures—for example, the freezing point (0°C) and boiling point (100°C) of water. You could first immerse the thermometer in an ice-water bath and mark the level at this point as 0°C. Then, immerse the thermometer in boiling water, and mark the level at this point as 100°C. As long as the two points are far enough apart to obtain readings of the desired accuracy, the thermometer can be used in experiments.

b. You could make 19 evenly spaced marks on the thermometer between the two original points, each representing a difference of 5°C. You may divide the space between the two original points into fewer spaces as long as you can read the thermometer to obtain the desired accuracy.

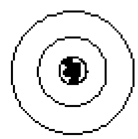
1.28. a.



b.



c.



1.29. a. To answer this question, you need to develop an equation that converts between °F and °YS. To do so, you need to recognize that one degree on the Your Scale does not correspond to one degree on the Fahrenheit scale and that −100°F corresponds to 0° on Your Scale (different “zero” points). As stated in the problem, in the desired range of 100 Your Scale degrees, there are 120 Fahrenheit degrees. Therefore, the relationship can be expressed as 120°F = 100°YS, since it covers the same temperature range. Now you need to “scale” the two systems so that they correctly convert from one scale to the other. You could set up an equation with the known data points and then employ the information from the relationship above.

For example, to construct the conversion between °YS and °F, you could perform the following steps:

Step 1: °F = °YS

Not a true statement, but one you would like to make true.

Step 2: $^\circ\text{F} = ^\circ\text{YS} \times \dfrac{120^\circ\text{F}}{100^\circ\text{YS}}$

This equation takes into account the difference in the size between the temperature unit on the two scales but will not give you the correct answer because it doesn’t take into account the different zero points.

Step 3: By subtracting 100°F from your equation from Step 2, you now have the complete equation that converts between °F and °YS.

$$^\circ\text{F} = \left(^\circ\text{YS} \times \frac{120^\circ\text{F}}{100^\circ\text{YS}}\right) - 100^\circ\text{F}$$

b. Using the relationship from part a, 66°YS is equivalent to

$$\left(66^\circ\text{YS} \times \frac{120^\circ\text{F}}{100^\circ\text{YS}}\right) - 100^\circ\text{F} = -2\underline{0}.8^\circ\text{F} = -21^\circ\text{F}$$

1.30. Some physical properties you could measure are density, hardness, color, and conductivity. Chemical properties of sodium would include reaction with air, reaction with water, reaction with chlorine, reaction with acids, bases, etc.

1.31. The empty boxes are identical, so they don't contribute to any mass or density difference. In packing the boxes with wooden cubes, it is simple to show that 125 wooden cubes will fit neatly into a box with no significant pockets of air, or void spaces, remaining in the packed box. Alternatively, as you will learn later in discussions on crystal structure, packing the box with wooden spheres depends on how the spheres pack. In terms of space utilization, the least efficient packing pattern involves spheres packed directly on top of each other; in other words, spheres would pack directly centered into positions where the wooden cubes would be, so 125 spheres would go in the box. A more efficient packing pattern results if the spheres occupy "valley" spots made available between every set of 3 spheres on adjacent layers; in such cases, more spheres than cubes would pack into the box. Regardless of the number of spheres packed into a box, there will still exist significant void space between the packed spheres that is filled with air which is much less dense than wood. As a result, the box containing the spheres will be less efficiently packed with actual wood. You can thus conclude that the box containing the cubes must have a greater mass of wood; hence, it must have a greater density.

1.32. a. Since the bead is less dense than any of the liquids in the container, the bead will float on top of all the liquids.

b. First, determine the density of the plastic bead. Since density is mass divided by volume, you get

$$d = \frac{m}{V} = \frac{3.92 \times 10^{-2}\ \text{g}}{0.043\ \text{mL}} = 0.9\underline{1}1\ \text{g/mL} = 0.91\ \text{g/mL}$$

Thus, the glass bead will pass through the top three layers and float on the ethylene glycol layer, which is more dense.

c. Since the bead sinks all the way to the bottom, it must be more dense than 1.114 g/mL.

1.33. a. A paper clip has a mass of about 1 g.

b. Answers will vary depending on your particular sample. Keeping in mind that the SI unit for mass is kg, the approximate weights for the items presented in the problem are as follows: a grain of sand, 1×10^{-5} kg; a paper clip, 1 x 10^{-3} kg; a nickel, 5×10^{-3} kg; a 5.0-gallon bucket of water, 2.0×10^{1} kg; a brick, 3 kg; a car, 1×10^{3} kg.

1.34. When taking measurements, never throw away meaningful information even if there is some uncertainty in the final digit. In this case, you are certain that the nail is between 5 and 6 cm. The uncertain, yet still important, digit is between the 5 and 6 cm measurements. You can estimate with reasonable precision that it is about 0.7 cm from the 5 cm mark, so an acceptable answer would be 5.7 cm. Another person might argue that the length of the nail is closer to 5.8 cm, which is also acceptable given the precision of the ruler. In any case, an answer of 5.7 or 5.8 should provide useful information about the length of the nail. If you were to report the length of the nail as 6 cm, you would be discarding potentially useful length information provided by the measuring instrument. If a higher degree of measurement precision were needed (more significant figures), you would need to switch to a more precise ruler—for example, one that had mm markings.

1.35. a. The number of significant figures in this answer follows the rules for multiplication and division. Here, the measurement with the fewest significant figures is the reported volume $0.310\ m^3$, which has three. Therefore, the answer will have three significant figures. Since Volume = L x W x H, you can rearrange and solve for one of the measurements, say the length.

$$L = \frac{V}{W \times H} = \frac{0.310\ m^3}{(0.7120\ m)\ (0.52145\ m)} = 0.83\underline{4}96\ m = 0.835\ m$$

b. The number of significant figures in this answer follows the rules for addition and subtraction. The measurement with the least number of decimal places is the result 1.509 m, which has three. Therefore, the answer will have three decimal places. Since the result is the sum of the three measurements, the third length is obtained by subtracting the other two measurements from the total.

Length = 1.509 m − 0.7120 m − 0.52145 m = $0.27\underline{5}55$ m = 0.276 m

1.36. The mass of something (how heavy it is) depends on how much of the item, material, substance, or collection of things you have. The density of something is the mass of a specific amount (volume) of an item, material, substance, or collection of things. You could use 1 kg of feathers and 1 kg of water to illustrate that they have the same mass yet have very different volumes; therefore, they have different densities.

■ SOLUTIONS TO PRACTICE PROBLEMS

Note on significant figures: If the final answer to a solution needs to be rounded off, it is given first with one nonsignificant figure, and the last significant figure is underlined. The final answer is then rounded to the correct number of significant figures. In multistep problems, intermediate answers are given with at least one nonsignificant figure; however, only the final answer has been rounded off.

1.37. By the law of conservation of mass:

Mass of sodium carbonate + mass of acetic acid solution = mass of contents of reaction vessel + mass of carbon dioxide

Plugging in gives

15.5 g + 19.7 g = 28.7 g + mass of carbon dioxide

Mass of carbon dioxide = 15.5 g + 19.7 g – 28.7 g = 6.5 g

1.38. By the law of conservation of mass:

Mass of iron + mass of acid = mass of contents of beaker + mass of hydrogen

Plugging in gives

5.6 g + 15.0 = 20.4 g + mass of hydrogen

Mass of hydrogen = 5.6 g + 15.0 g − 20.4 g = 0.2 g

1.39. By the law of conservation of mass:

Mass of zinc + mass of sulfur = mass of zinc sulfide

Rearranging and plugging in give

Mass of zinc sulfide = 65.4 g + 32.1 g = 97.5 g

For the second part, let x = mass of zinc sulfide that could be produced. By the law of conservation of mass:

36.9 g + mass of sulfur = x

Write a proportion that relates the mass of zinc reacted to the mass of zinc sulfide formed, which should be the same for both cases.

$$\frac{\text{mass zinc}}{\text{mass zinc sulfide}} = \frac{65.4\text{ g}}{97.5\text{ g}} = \frac{36.9\text{ g}}{x}$$

Solving gives $x = 55.\underline{0}1$ g = 55.0 g

1.40. By the law of conservation of mass:

Mass of aluminum + mass of bromine = mass of aluminum bromide

Plugging in and solving give

27.0 g + Mass of bromine = 266.7 g

Mass of bromine = 266.7 g − 27.0 g = 239.7 g

For the second part, let x = mass of bromine that reacts. By the law of conservation of mass:

18.1 g + x = mass of aluminum bromide

Write a proportion that relates the mass of aluminum reacted to the mass of bromine reacted, which should be the same for both cases.

$$\frac{\text{mass aluminum}}{\text{mass bromine}} = \frac{27.0\text{ g}}{239.7\text{ g}} = \frac{18.1\text{ g}}{x}$$

Solving gives $x = 16\underline{0}.7$ g = 161 g

1.41. a. Solid b. Liquid c. Gas d. Solid

1.42. a. Solid b. Solid c. Solid d. Liquid

1.43. a. Physical change

b. Physical change

c. Chemical change

d. Physical change

1.44. a. Physical change

b. Chemical change

c. Chemical change

d. Physical change

1.45. Physical change: Liquid mercury is cooled to solid mercury.

Chemical changes: (1) Solid mercury oxide forms liquid mercury metal and gaseous oxygen; (2) glowing wood and oxygen form burning wood (form ash and gaseous products).

1.46. Physical changes: (1) Solid iodine is heated to gaseous iodine; (2) gaseous iodine is cooled to form solid iodine.

Chemical change: Solid iodine and zinc metal are ignited to form a white powder.

1.47. a. Physical property
b. Chemical property
c. Physical property
d. Physical property
e. Chemical property

1.48. a. Physical property
b. Chemical property
c. Physical property
d. Chemical property
e. Physical property

1.49. Physical properties: (1) Iodine is solid; (2) the solid has lustrous blue-black crystals; (3) the crystals vaporize readily to a violet-colored gas.

Chemical properties: (1) Iodine combines with many metals, such as with aluminum to give aluminum iodide.

1.50. Physical properties: (1) is a solid; (2) has an orange-red color; (3) has a density of 11.1 g/cm^3; (4) is insoluble in water.

Chemical property: Mercury(II) oxide decomposes when heated to give mercury and oxygen.

1.51. a. Physical process
b. Chemical reaction
c. Physical process
d. Chemical reaction
e. Physical process

1.52. a. Chemical reaction
b. Physical process
c. Physical process
d. Physical process
e. Chemical reaction

1.53. a. Solution
b. Substance
c. Substance
d. Heterogeneous mixture

1.54. a. Homogeneous mixture, if fresh; heterogeneous mixture, if spoiled

b. Substance

c. Solution

d. Substance

1.55. a. A pure substance with two phases present, liquid and gas.

b. A mixture with two phases present, solid and liquid.

c. A pure substance with two phases present, solid and liquid.

d. A mixture with two phases present, solid and solid.

1.56. a. A mixture with two phases present, solid and liquid.

b. A mixture with two phases present, solid and liquid.

c. A mixture with two phases present, solid and solid.

d. A pure substance with two phases present, liquid and gas.

1.57. a. four

b. three

c. four

d. five

e. three

f. four

1.58. a. five

b. four

c. two

d. four

e. three

f. four

1.59. $4\underline{0},000 \text{ km} = 4.0 \text{ x } 10^4 \text{ km}$

1.60. $15\underline{0},000,000 \text{ km} = 1.50 \times 10^8 \text{ km}$

1.61. a. $\dfrac{8.71 \times 0.0301}{0.031} = 8.\underline{4}57 = 8.5$

b. $0.71 + 89.3 = 90.\underline{0}1 = 90.0$

c. $934 \times 0.00435 + 107 = 4.0\underline{6}29 + 107 = 11\underline{1}.06 = 111$

d. $(847.89 - 847.73) \times 14673 = 0.1\underline{6} \times 14673 = 2\underline{3}47 = 2.3 \times 10^3$

1.62. a. $\dfrac{8.71 \times 0.57}{5.871} = 0.8\underline{4}56 = 0.85$

b. $8.937 - 8.930 = 0.007$

c. $8.937 + 8.930 = 17.867$

d. $0.00015 \times 54.6 + 1.002 = 0.008\underline{1}9 + 1.002 = 1.01\underline{0}1 = 1.010$

1.63. The volume of the first sphere is

$$V_1 = (4/3)\pi r^3 = (4/3)\pi \times (4.52\text{ cm})^3 = 38\underline{6}.82\text{ cm}^3$$

The volume of the second sphere is

$$V_2 = (4/3)\pi r^3 = (4/3)\pi \times (4.72\text{ cm})^3 = 44\underline{0}.47\text{ cm}^3$$

The difference in volume is

$$V_2 - V_1 = 44\underline{0}.47\text{ cm}^3 - 38\underline{6}.82\text{ cm}^3 = 5\underline{3}.65\text{ cm}^3 = 54\text{ cm}^3$$

1.64. The length of the cylinder between the two marks is

$$l = 3.50\text{ cm} - 3.20\text{ cm} = 0.3\underline{0}\text{ cm}$$

The volume of iron contained between the marks is

$$V = \pi r^2 l = \pi \times (1.500\text{ cm})^2 \times 0.3\underline{0}\text{ cm} = 2.\underline{1}2\text{ cm}^3 = 2.1\text{ cm}^3$$

1.65. a. 5.89×10^{-12} s = 5.89 ps

b. 0.2010 m = 2.01 dm

c. 2.560×10^{-9} g = 2.560 ng

d. 6.05×10^{3} m = 6.05 km

1.66. a. 4.851×10^{-6} g = 4.851 μg

b. 3.16×10^{-2} m = 3.16 cm

c. 2.591×10^{-9} s = 2.591 ns

d. 8.93×10^{-12} g = 8.93 pg

1.67. a. 6.15 ps = 6.15×10^{-12} s

b. 3.781 μm = 3.781×10^{-6} m

c. 1.546 Å = 1.546×10^{-10} m

d. 9.7 mg = 9.7×10^{-3} g

1.68. a. 6.20 km = 6.20×10^{3} m

b. 1.98 ns = 1.98×10^{-9} s

c. 2.54 cm = 2.54×10^{-2} m

d. 5.23 μg = 5.23×10^{-6} g

1.69. a. $t_C = \frac{5°C}{9°F} \times (t_F - 32°F) = \frac{5°C}{9°F} \times (68°F - 32°F) = 2\underline{0}.0°C = 20.°C$

b. $t_C = \frac{5°C}{9°F} \times (t_F - 32°F) = \frac{5°C}{9°F} \times (-23°F - 32°F) = -3\underline{0}.56°C = -31°C$

c. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (26°C \times \frac{9°F}{5°C}) + 32°F = 7\underline{8}.8°F = 79°F$

d. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (-81°C \times \frac{9°F}{5°C}) + 32°F = -11\underline{3}.8°F = -114°F$

1.70. a. $t_C = \frac{5°C}{9°F} \times (t_F - 32°F) = \frac{5°C}{9°F} \times (51°F - 32°F) = 1\underline{0}.556°C = 11°C$

b. $t_C = \frac{5°C}{9°F} \times (t_F - 32°F) = \frac{5°C}{9°F} \times (-11°F - 32°F) = -2\underline{3}.9°C = -24°C$

c. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (-41°C \times \frac{9°F}{5°C}) + 32°F = -4\underline{1}.8°F = -42°F$

d. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (22°C \times \frac{9°F}{5°C}) + 32°F = 7\underline{1}.6°F = 72°F$

1.71. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (-20.0°C \times \frac{9°F}{5°C}) + 32°F = -4.\underline{0}°F = -4.0°F$

1.72. $t_F = (t_C \times \frac{9°F}{5°C}) + 32°F = (-222.7°C \times \frac{9°F}{5°C}) + 32°F = -368.\underline{8}6°F = -368.9°F$

1.73. $d = \frac{m}{V} = \frac{12.4\text{ g}}{1.64\text{ cm}^3} = 7.5\underline{6}0\text{ g/cm}^3 = 7.56\text{ g/cm}^3$

1.74. $d = \frac{m}{V} = \frac{23.6\text{ g}}{30.0\text{ mL}} = 0.78\underline{6}7\text{ g/mL} = 0.787\text{ g/mL}$

1.75. First, determine the density of the liquid.

$$d = \frac{m}{V} = \frac{6.71\text{ g}}{8.5\text{ mL}} = 0.7\underline{8}94 = 0.79\text{ g/mL}$$

The density is closest to ethanol (0.789 g/cm^3).

1.76. First, determine the density of the mineral sample.

$$d = \frac{m}{V} = \frac{5.94\text{ g}}{0.73\text{ cm}^3} = 8.\underline{1}37 = 8.1\text{ g/cm}^3$$

The density is closest to cinnabar (8.10 g/cm^3).

1.77. The mass of platinum is obtained as follows.

Mass = $d \times V = 21.4\text{ g/cm}^3 \times 5.9\text{ cm}^3 = 1\underline{2}6\text{ g} = 1.3 \times 10^2\text{ g}$

1.78. The mass of gasoline is obtained as follows.

$$\text{Mass} = d \times V = 0.70\ \text{g/mL} \times 43.8\ \text{mL} = 3\underline{0}.66\ \text{g} = 31\ \text{g}$$

1.79. The volume of ethanol is obtained as follows. Recall that 1 mL = 1 cm^3.

$$\text{Volume} = \frac{m}{d} = \frac{19.8\ \text{g}}{0.789\ \text{g/cm}^3} = 25.\underline{0}9\ \text{cm}^3 = 25.1\ \text{cm}^3 = 25.1\ \text{mL}$$

1.80. The volume of bromine is obtained as follows.

$$\text{Volume} = \frac{m}{d} = \frac{88.5\ \text{g}}{3.10\ \text{g/mL}} = 28.\underline{5}4\ \text{mL} = 28.5\ \text{mL}$$

1.81. Since 1 kg = 10^3 g, and 1 mg = 10^{-3} g, you can write

$$0.450\ \text{kg x}\ \frac{10^3\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mg}}{10^{-3}\ \text{g}} = 4.50 \times 10^5\ \text{mg}$$

1.82. Since 1 mg = 10^{-3} g, and 1 μg = 10^{-6} g, you can write

$$611\ \text{mg x}\ \frac{10^{-3}\ \text{g}}{1\ \text{mg}} \times \frac{1\ \mu\text{g}}{10^{-6}\ \text{g}} = 6.11 \times 10^5\ \mu\text{g}$$

1.83. Since 1 nm = 10^{-9} m, and 1 cm = 10^{-2} m, you can write

$$555\ \text{nm} \times \frac{10^{-9}\ \text{m}}{1\ \text{nm}} \times \frac{1\ \text{cm}}{10^{-2}\ \text{m}} = 5.55 \times 10^{-5}\ \text{cm}$$

1.84. Since 1 Å = 10^{-10} m, and 1 mm = 10^{-3} m, you can write

$$0.96\ \text{Å} \times \frac{10^{-10}\ \text{m}}{1\ \text{Å}} \times \frac{1\ \text{mm}}{10^{-3}\ \text{m}} = 9.6 \times 10^{-8}\ \text{mm}$$

1.85. Since 1 km = 10^3 m, you can write

$$3.73 \times 10^8\ \text{km}^3 \times \left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)^3 = 3.73 \times 10^{17}\ \text{m}^3$$

Now, 1 dm = 10^{-1} m. Also, note that 1 dm^3 = 1 L. Therefore, you can write

$$3.73 \times 10^{17}\ \text{m}^3 \times \left(\frac{1\ \text{dm}}{10^{-1}\ \text{m}}\right)^3 = 3.73 \times 10^{20}\ \text{dm}^3 = 3.73 \times 10^{20}\ \text{L}$$

1.86. 1 μm = 10^{-6} m, and 1 dm = 10^{-1} m. Also, note that 1 dm^3 = 1 L. Therefore, you can write

$$1.3\ \mu\text{m}^3 \times \left(\frac{10^{-6}\ \text{m}}{1\ \mu\text{m}}\right)^3 \times \left(\frac{1\ \text{dm}}{10^{-1}\ \text{m}}\right)^3 = 1.3 \times 10^{-15}\ \text{dm}^3 = 1.3 \times 10^{-15}\ \text{L}$$

1.87. $$3.58\ \text{short ton x}\ \frac{2000\ \text{lb}}{1\ \text{short ton}} \times \frac{16\ \text{oz}}{1\ \text{lb}} \times \frac{1\ \text{g}}{0.03527\ \text{oz}} = 3.2\underline{4}8 \times 10^6\ \text{g} = 3.25 \times 10^6\ \text{g}$$

1.88. $3.15 \text{ Btu} \times \frac{252.0 \text{ cal}}{1 \text{ Btu}} \times \frac{4.184 \text{ J}}{1 \text{ cal}} = 33\underline{2}1 \text{ J} = 3.32 \times 10^3 \text{ J}$

1.89. $2425 \text{ fathoms} \times \frac{6 \text{ ft}}{1 \text{ fathom}} \times \frac{12 \text{ in.}}{1 \text{ ft}} \times \frac{2.54 \times 10^{-2} \text{ m}}{1 \text{ in.}} = 443\underline{4}.8 \text{ m} = 4.435 \times 10^3 \text{ m}$

1.90. $1.3 \text{ x } 10^{10} \text{ barrels} \times \frac{42 \text{ gal}}{1 \text{ barrel}} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{9.46 \text{ x } 10^{-4} \text{ m}^3}{1 \text{ qt}} = 2.\underline{0}66 \times 10^9 \text{ m}^3 = 2.1 \text{ x } 10^9 \text{ m}^3$

1.91. $(24.2 \text{ in.}) \times (15.9 \text{ in.}) \times (14.8 \text{ in.}) \times \left(\frac{2.54 \text{ cm}}{1 \text{ in.}}\right)^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 93.\underline{3}2 \text{ L} = 93.3 \text{ L}$

1.92. $(1.00 \text{ km}) \times (2.0 \text{ km}) \times (1 \text{ m}) \times \left(\frac{1000 \text{ m}}{1 \text{ km}}\right)^2 \times \frac{33 \text{ worms}}{1 \text{ m}^3} = 6.\underline{6}0 \times 10^7 = 6.6 \times 10^7 \text{ worms}$

■ SOLUTIONS TO GENERAL PROBLEMS

1.93. From the law of conservation of mass,

Mass of sodium + mass of water = mass of hydrogen + mass of solution

Substituting, you obtain

19.70 g + 126.22 g = mass of hydrogen + 145.06 g

or,

Mass of hydrogen = 19.70 g + 126.22 g − 145.06 g = 0.8$\underline{6}$ g

Thus, the mass of hydrogen produced was 0.86 g.

1.94. From the law of conservation of mass,

Mass of tablet + mass of acid solution = mass of carbon dioxide + mass of solution

Substituting, you obtain

0.853 g + 56.519 g = mass of carbon dioxide + 57.152 g

Mass of carbon dioxide = 0.853 g + 56.519 g − 57.152 g = 0.22$\underline{0}$ g

Thus, the mass of carbon dioxide produced was 0.220 g.

1.95. From the law of conservation of mass,

Mass of aluminum + mass of iron(III) oxide = mass of iron +

mass of aluminum oxide + mass of unreacted iron(III) oxide

5.40 g + 18.50 g = 11.17 g + 10.20 g + mass of iron(III) oxide unreacted

Mass of iron(III) oxide unreacted = 5.40 g + 18.50 g − 11.17 g − 10.20 g = 2.53 g

Thus, the mass of unreacted iron(III) oxide is 2.53 g.

1.96. From the law of conservation of mass,

Mass of sodium bromide + mass of chlorine reacted = mass of bromine + mass of sodium chloride

20.6 g + mass of chlorine reacted = 16.0 g + 11.7 g

Mass of chlorine reacted = 16.0 g + 11.7 g − 20.6 g = 7.$\underline{1}$ g

Thus, the mass of chlorine that reacted is 7.1 g.

1.97. 50.90 g + 5.680 g + 53.3 g = 109.$\underline{8}$8 g = 109.9 g total

1.98. 66.5 g + 58.2 g + 5.279 g = 129.$\underline{9}$79 g = 130.0 g total

1.99. a. Chemical b. Physical c. Physical d. Chemical

1.100. a. Physical b. Chemical c. Physical d. Chemical

1.101. Compounds always contain the same proportions of the elements by mass. Thus, if we let X be the proportion of iron in a sample, we can calculate the proportion of iron in each sample as follows.

Sample A: $X = \dfrac{\text{mass of iron}}{\text{mass of sample}} = \dfrac{1.094\text{ g}}{1.518\text{ g}} = 0.720\underline{6}8 = 0.7207$

Sample B: $X = \dfrac{\text{mass of iron}}{\text{mass of sample}} = \dfrac{1.449\text{ g}}{2.056\text{ g}} = 0.704\underline{7}6 = 0.7048$

Sample C: $X = \dfrac{\text{mass of iron}}{\text{mass of sample}} = \dfrac{1.335\text{ g}}{1.873\text{ g}} = 0.712\underline{7}6 = 0.7128$

Since each sample has a different proportion of iron by mass, the material is not a compound.

1.102. Compounds always contain the same proportions of the elements by mass. Thus, if we let X be the proportion of mercury in a sample, we can calculate the proportion of mercury in each sample as follows.

Sample A: $X = \dfrac{\text{mass of mercury}}{\text{mass of sample}} = \dfrac{0.9641\text{ g}}{1.0410\text{ g}} = 0.926\underline{1}2 = 0.9261$

Sample B: $X = \dfrac{\text{mass of mercury}}{\text{mass of sample}} = \dfrac{1.4293\text{ g}}{1.5434\text{ g}} = 0.926\underline{0}7 = 0.9261$

Sample C: $X = \dfrac{\text{mass of mercury}}{\text{mass of sample}} = \dfrac{1.1283\text{ g}}{1.2183\text{ g}} = 0.926\underline{1}2 = 0.9261$

Since each sample has the same proportion of mercury by mass, the data are consistent with the hypothesis that the material is a compound.

1.103. $V = (\text{edge})^3 = (39.3\text{ cm})^3 = 6.0\underline{6}9 \times 10^4\text{ cm}^3 = 6.07 \times 10^4\text{ cm}^3$

1.104. $V = \pi r^2 l = \pi \times (2.56\text{ cm})^2 \times 56.32\text{ cm} = 11\underline{5}9\text{ cm}^3 = 1.16 \times 10^3\text{ cm}^3$

1.105. $V = LWH = 47.8 \text{ in.} \times 12.5 \text{ in.} \times 19.5 \text{ in.} \times \dfrac{1 \text{ gal}}{231 \text{ in}^3} = 50.\underline{4}3 \text{ gal} = 50.4 \text{ gal}$

1.106. The volume in cubic inches is

$$V = (4/3)\pi r^3 = (4/3)\pi \times (175.0 \text{ in.})^3 = 2.24\underline{4}92 \times 10^7 \text{ in}^3 = 2.245 \times 10^7 \text{ in}^3$$

The volume in imperial gallons is

$$V = 2.24\underline{4}92 \text{ x } 10^7 \text{ in}^3 \times \frac{1 \text{ gal}}{277.4 \text{ in}^3} = 8.09\underline{2}75 \times 10^4 \text{ gal} = 8.093 \times 10^4 \text{ gal}$$

1.107. The volume of the first sphere is given by

$$V_1 = (4/3)\pi r^3 = (4/3)\pi \times (5.61 \text{ cm})^3 = 73\underline{9}.5 \text{ cm}^3$$

The volume of the second sphere is given by

$$V_2 = (4/3)\pi r^3 = (4/3)\pi \times (5.85 \text{ cm})^3 = 83\underline{8}.6 \text{ cm}^3$$

The difference in volume between the two spheres is given by

$$V = V_2 - V_1 = 83\underline{8}.6 \text{ cm}^3 - 73\underline{9}.5 \text{ cm}^3 = 9.\underline{9}1 \times 10^1 = 9.9 \times 10^1 \text{ cm}^3$$

1.108. The surface area of the first circle is given by

$$S_1 = \pi r^2 = \pi \times (7.98 \text{ cm})^2 = 20\underline{0}.0 \text{ cm}^2$$

The surface area of the second circle is given by

$$S_2 = \pi r^2 = \pi \times (8.50 \text{ cm})^2 = 22\underline{6}.9 \text{ cm}^2$$

The difference in surface area between the two circles is

Difference = $S_2 - S_1 = 22\underline{6}.9 \text{ cm}^2 - 20\underline{0}.0 \text{ cm}^2 = 2\underline{6}.9 \text{ cm}^2 = 27 \text{ cm}^2$

1.109. a. $\dfrac{56.1\text{- } 51.1}{6.58} = 7.59 \times 10^{-1} = 7.6 \times 10^{-1}$

b. $\dfrac{56.1 + 51.1}{6.58} = 1.6\underline{2}9 \times 10^1 = 1.63 \times 10^1$

c. $(9.1 + 8.6) \times 26.91 = 4.7\underline{6}3 \times 10^2 = 4.76 \times 10^2$

d. $0.0065 \times 3.21 + 0.0911 = 1.1\underline{1}9 \times 10^{-1} = 1.12 \times 10^{-1}$

1.110. a. $\dfrac{9.345 - 9.005}{9.811} = 0.034\underline{6}5 = 0.0347$

b. $\dfrac{9.345 + 9.005}{9.811} = 1.87\underline{0}3 = 1.870$

c. $(7.50 + 7.53) \times 3.71 = 55.\underline{7}61 = 55.8$

d. $0.71 \times 0.36 + 17.36 = 17.6\underline{1}56 = 17.62$

1.111. a. 9.12 cg

b. 66 pm

c. 7.1 µm

d. 56 nm

1.112. a. 1.86 cg

b. 77 pm

c. 6.5 nm

d. 0.85 µm

1.113. a. 1.07×10^{-12} s

b. 5.8×10^{-6} m

c. 3.19×10^{-7} m

d. 1.53×10^{-2} s

1.114. a. 6.6×10^{-3} K

b. 2.75×10^{-10} m

c. 2.21×10^{-2} s

d. 4.5×10^{-5} m

1.115. $t_F = (t_C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = (3410^\circ C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = 617\underline{0}^\circ F = 6170^\circ F$

1.116. $t_F = (t_C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = (1677^\circ C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = 305\underline{0}.6^\circ F = 3051^\circ F$

1.117. $t_F = (t_C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = (825^\circ C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = 15\underline{1}7^\circ F = 1.52 \text{ x } 10^3 {}^\circ F$

1.118. $t_F = (t_C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = (50^\circ C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = 12\underline{2}^\circ F = 122^\circ F$ (more likely 120 °F)

1.119. The temperature in kelvins is

$$T_K = (t_C \times \frac{1 \text{ K}}{1^\circ C}) + 273.15 \text{ K} = (29.8^\circ C \times \frac{1 \text{ K}}{1^\circ C}) + 273.15 \text{ K} = 302.\underline{9}5 \text{ K}$$
$$= 303.0 \text{ K}$$

The temperature in degrees Fahrenheit is

$$t_F = (t_C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = (29.8^\circ C \times \frac{9^\circ F}{5^\circ C}) + 32^\circ F = 85.\underline{6}4^\circ F = 85.6^\circ F$$

1.120. The temperature in kelvins is

$$T_K = (t_C \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = (-38.9°\text{C} \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = 234.25\text{ K}$$

$= 234.3$ K

The temperature in degrees Fahrenheit is

$$t_F = (t_C \times \frac{9°\text{F}}{5°\text{C}}) + 32°\text{F} = (-38.9°\text{C} \times \frac{9°\text{F}}{5°\text{C}}) + 32°\text{F} = -38.\underline{0}2°\text{F} = -38.0°\text{F}$$

1.121. The temperature in degrees Celsius is

$$t_C = \frac{5°\text{C}}{9°\text{F}} \times (t_F - 32°\text{F}) = \frac{5°\text{C}}{9°\text{F}} \times (1666°\text{F} - 32°\text{F}) = 907.\underline{7}7°\text{C} = 907.8°\text{C}$$

The temperature in kelvins is

$$T_K = (t_C \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = (907.\underline{7}7°\text{C} \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = 1180.\underline{9}2\text{ K}$$

$= 1180.9$ K

1.122. The temperature in degrees Celsius is

$$t_C = \frac{5°\text{C}}{9°\text{F}} \times (t_F - 32°\text{F}) = \frac{5°\text{C}}{9°\text{F}} \times (236°\text{F} - 32°\text{F}) = 11\underline{3}.3°\text{C} = 113°\text{C}$$

The temperature in kelvins is

$$T_K = (t_C \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = (11\underline{3}.3°\text{C} \times \frac{1\text{ K}}{1°\text{C}}) + 273.15\text{ K} = 386.4\text{ K}$$

$= 386$ K

1.123. $$\text{Density} = \frac{2.70\text{ g}}{1\text{ cm}^3} \times \frac{1\text{ kg}}{10^3\text{ g}} \times \left(\frac{1\text{ cm}}{10^{-2}\text{ m}}\right)^3 = 2.70 \times 10^3\text{ kg/m}^3$$

1.124. $$\text{Density} = \frac{5.96\text{ g}}{1\text{ cm}^3} \times \frac{1\text{ kg}}{10^3\text{ g}} \times \left(\frac{1\text{ cm}}{10^{-2}\text{ m}}\right)^3 = 5.96 \times 10^3\text{ kg/m}^3$$

1.125. The volume of the quartz is 67.1 mL − 52.2 mL = 14.9 mL. Then, the density is

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{39.8\text{ g}}{14.9\text{ mL}} = 2.6\underline{7}1\text{ g/mL} = 2.67\text{ g/mL} = 2.67\text{ g/cm}^3$$

1.126. First, determine the volume of water in the flask. The mass of water is obtained as follows. 109.3 g − 70.7 g = 38.6 g. Now, using the density (0.997 g/cm^3),

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{38.6\text{ g}}{0.997\text{ g/ cm}^3} = 38.\underline{7}16\text{ cm}^3 = 38.\underline{7}16\text{ mL}$$

Now, the volume of the ore is 53.2 mL − 38.$\underline{7}$16 mL = 14.$\underline{4}$8 mL, or 14.$\underline{4}$8 cm^3. Therefore, the density of the hematite ore is

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{70.7\text{ g}}{14.\underline{4}8\text{ cm}^3} = 4.8\underline{8}1\text{ g/cm}^3 = 4.88\text{ g/cm}^3$$

1.127. First, determine the density of the liquid sample.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{22.3\text{ g}}{15.0\text{ mL}} = 1.4\underline{8}6\text{ g/mL} = 1.49\text{ g/mL} = 1.49\text{ g/cm}^3$$

This density is closest to that of chloroform (1.489 g/cm^3), so the unknown liquid is chloroform.

1.128. First, determine the density of the calcite sample.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{35.6\text{ g}}{12.9\text{ cm}^3} = 2.7\underline{5}9\text{ g/cm}^3 = 2.76\text{ g/cm}^3$$

Since a substance will float on the liquids with greater densities, calcite will float on tetrabromoethane (2.96 g/cm^3) and methylene iodode (3.33 g/cm^3).

1.129. First, determine the volume of the cube of platinum.

$$V = (\text{edge})^3 = (4.40\text{ cm})^3 = 85.\underline{1}8\text{ cm}^3$$

Now, use the density to determine the mass of the platinum.

$$\text{Mass} = d \text{ x } V = 21.4\text{ g/cm}^3 \times 85.\underline{1}8\text{ cm}^3 = 18\underline{2}2.9\text{ g} = 1.82 \times 10^3\text{ g}$$

1.130. First, determine the volume of the cylinder of silicone.

$$V = \pi r^2 l = \pi \text{ x } (4.00\text{ cm})^2 \times 12.40\text{ cm} = 623.\underline{2}9\text{ cm}^3$$

Now, use the density to determine the mass of the silicon.

$$\text{Mass} = d \times V = 2.33\text{ g/cm}^3 \text{ x } 623.\underline{2}9\text{ cm}^3 = 14\underline{5}2.2\text{ g} = 1.45 \times 10^3\text{ g}$$

1.131. $\text{Volume} = \dfrac{\text{mass}}{\text{density}} = \dfrac{35.00\text{ g}}{1.053\text{ g/ mL}} = 33.2\underline{3}8\text{ mL} = 33.24\text{ mL}$

1.132. First, convert kilograms to grams (1 kg = 10^3 g). Thus, 0.070 kg = 70 g. Then

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{70\text{ g}}{0.902\text{ g/ mL}} = 7\underline{7}.61\text{ mL}$$

Finally, convert the volume to liters (1000 mL = 1 L).

$$\text{Volume} = 7\underline{7}.61\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.07\underline{7}61\text{ L} = 0.078\text{ L}$$

1.133. a. $8.45\text{ kg} \times \dfrac{10^3\text{ g}}{1\text{ kg}} \times \dfrac{1\ \mu\text{g}}{10^{-6}\text{ g}} = 8.45 \times 10^9\ \mu\text{g}$

b. $318\ \mu\text{s} \times \dfrac{10^{-6}\text{ s}}{1\ \mu\text{s}} \times \dfrac{1\text{ ms}}{10^{-3}\text{ s}} = 3.18 \times 10^{-1}\text{ ms}$

c. $93\text{ km} \times \dfrac{10^3\text{ m}}{1\text{ km}} \times \dfrac{1\text{ nm}}{10^{-9}\text{ m}} = 9.3 \times 10^{13}\text{ nm}$

d. $37.1\text{ mm} \times \dfrac{10^{-3}\text{ m}}{1\text{ mm}} \times \dfrac{1\text{ cm}}{10^{-2}\text{ m}} = 3.71\text{ cm}$

1.134. a. $127\ \text{Å} \times \dfrac{10^{-10}\ \text{m}}{1\ \text{Å}} \times \dfrac{1\ \mu\text{m}}{10^{-6}\ \text{m}} = 1.27 \times 10^{-2}\ \mu\text{m}$

b. $21.0\ \text{kg} \times \dfrac{10^{3}\ \text{g}}{1\ \text{kg}} \times \dfrac{1\ \text{mg}}{10^{-3}\ \text{g}} = 2.10 \times 10^{7}\ \text{mg}$

c. $1.09\ \text{cm}\ \text{x}\ \dfrac{10^{-2}\ \text{m}}{1\ \text{cm}} \times \dfrac{1\ \text{mm}}{10^{-3}\ \text{m}} = 10.9\ \text{mm}$

d. $4.6\ \text{ns} \times \dfrac{10^{-9}\ \text{s}}{1\ \text{ns}} \times \dfrac{1\ \mu\text{s}}{10^{-6}\ \text{s}} = 4.6 \times 10^{-3}\ \mu\text{s}$

1.135. a. $5.91\ \text{kg} \times \dfrac{10^{3}\ \text{g}}{1\ \text{kg}} \times \dfrac{1\ \text{mg}}{10^{-3}\ \text{g}} = 5.91 \times 10^{6}\ \text{mg}$

b. $753\ \text{mg} \times \dfrac{10^{-3}\ \text{g}}{1\ \text{mg}} \times \dfrac{1\ \mu\text{g}}{10^{-6}\ \text{g}} = 7.53 \times 10^{5}\ \mu\text{g}$

c. $90.1\ \text{MHz} \times \dfrac{10^{6}\ \text{Hz}}{1\ \text{MHz}} \times \dfrac{1\ \text{kHz}}{10^{3}\ \text{Hz}} = 9.01 \times 10^{4}\ \text{kHz}$

d. $498\ \text{mJ} \times \dfrac{10^{-3}\ \text{J}}{1\ \text{mJ}} \times \dfrac{1\ \text{kJ}}{10^{3}\ \text{J}} = 4.98 \times 10^{-4}\ \text{kJ}$

1.136. a. $7.19\ \mu\text{g} \times \dfrac{10^{-6}\ \text{g}}{1\ \mu\text{g}} \times \dfrac{1\ \text{mg}}{10^{-3}\ \text{g}} = 7.19 \times 10^{-3}\ \text{mg}$

b. $104\ \text{pm} \times \dfrac{10^{-12}\ \text{m}}{1\ \text{pm}} \times \dfrac{1\ \text{Å}}{10^{-10}\ \text{m}} = 1.04\ \text{Å}$

c. $0.010\ \text{mm} \times \dfrac{10^{-3}\ \text{m}}{1\ \text{mm}} \times \dfrac{1\ \text{cm}}{10^{-2}\ \text{m}} = 1.0 \times 10^{-3}\ \text{cm}$

d. $0.0605\ \text{kPa} \times \dfrac{10^{3}\ \text{Pa}}{1\ \text{kPa}} \times \dfrac{1\ \text{cPa}}{10^{-2}\ \text{Pa}} = 6.05 \times 10^{3}\ \text{cPa}$

1.137. $\text{Volume} = 12{,}230\ \text{km}^3 \times \left(\dfrac{10^{3}\ \text{m}}{1\ \text{km}}\right)^3 \times \left(\dfrac{1\ \text{dm}}{10^{-1}\ \text{m}}\right)^3 \times \dfrac{1\ \text{L}}{1\ \text{dm}^3} = 1.2230 \times 10^{16}\ \text{L}$

1.138. $\text{Volume} = 3.50\ \text{km}^3 \times \left(\dfrac{10^{3}\ \text{m}}{1\ \text{km}}\right)^3 \times \left(\dfrac{1\ \text{dm}}{10^{-1}\ \text{m}}\right)^3 \times \dfrac{1\ \text{L}}{1\ \text{dm}^3} = 3.50 \times 10^{12}\ \text{L}$

1.139. First, calculate the volume of the room in cubic feet.

$\text{Volume} = LWH = 10.0\ \text{ft} \times 11.0\ \text{ft} \times 9.0\ \text{ft} = 9\underline{9}0\ \text{ft}^3$

Next, convert the volume to liters.

$V = 9\underline{9}0\ \text{ft}^3\ \text{x} \left(\dfrac{12\ \text{in}}{1\ \text{ft}}\right)^3 \times \left(\dfrac{2.54\ \text{cm}}{1\ \text{in}}\right)^3 \times \dfrac{1\ \text{L}}{10^{3}\ \text{cm}^3} = 2.\underline{8}0 \times 10^{4}\ \text{L} = 2.8 \times 10^{4}\ \text{L}$

1.140. First, calculate the volume of the cylinder in cubic feet.

$$\text{Volume} = \pi r^2 l = \pi \text{ x } (15.0 \text{ ft})^2 \text{ x } 5.0 \text{ ft} = 3\underline{5}34 \text{ ft}^3$$

Next, convert the volume to liters.

$$V = 3\underline{5}34 \text{ ft}^3 \times \left(\frac{12 \text{ in}}{1 \text{ ft}}\right)^3 \text{ x } \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 \times \frac{1 \text{ L}}{10^3 \text{ cm}^3} = 1.\underline{0}0 \times 10^5 \text{ L}$$

$$= 1.0 \times 10^5 \text{ L}$$

1.141. $\text{Mass} = 384 \text{ carats} \times \frac{200 \text{ mg}}{1 \text{ carat}} \times \frac{10^{-3} \text{ g}}{1 \text{ mg}} = 76.\underline{8}0 \text{ g} = 76.8 \text{ g}$

1.142. $\text{Mass} = 49.6 \times 10^6 \text{ troy oz} \times \frac{31.10 \text{ g}}{1 \text{ troy oz}} \times \frac{1 \text{ ton}}{10^6 \text{ g}} = 1.5\underline{4}2 \times 10^3 \text{ ton}$

$= 1.54 \times 10^3 \text{ ton}$

1.143. The adhesive is not permanent, is easily removable, and does no harm to the object.

1.144. The scientific question Art Fry was trying to answer was: "Is there an adhesive that will not permanently stick things together?"

1.145. Chromatography depends on how fast a substance moves in a stream of gas or liquid, past a stationary phase to which the substance is slightly attracted.

1.146. The moving stream is a gaseous mixture of vaporized substances plus a gas such as helium, the carrier. The gas is passed through a column containing a stationary phase. As the gas passes through the column, the substances are attracted differently to the stationary column packing and thus are separated. The separated gases pass through a detector, and the results are displayed graphically.

■ SOLUTIONS TO STRATEGY PROBLEMS

1.147. $5 \text{ x } 10^{-2} \text{ mg} = 0.05 \text{ mg}$. So $4.7 \text{ mg} - 0.05 \text{ mg} = 4.\underline{6}5 \text{ mg} = 4.7 \text{ mg}$

1.148. $V = \frac{m}{d} = \frac{33.0 \text{ g}}{0.797 \text{ g/cm}^3} = 41.\underline{4}05 = 41.4 \text{ cm}^3$

1.149. $V = V_A + V_B = \frac{m_A}{d_A} + 40.8 \text{ mL} = \frac{124 \text{ g}}{3.00 \text{ g/mL}} + 40.8 \text{ mL} = 41.\underline{3}3 \text{ mL} + 40.8 \text{ mL}$

$= 82.\underline{1}3 = 82.1 \text{ mL}$

1.150. a. $r = \frac{d}{t} = \frac{832 \text{ mi}}{21 \text{ h}} = 3\underline{9}.619 \text{ mi/h} = 40. \text{ mi/h}$

b. $\frac{832 \text{ mi}}{21 \text{ h}} \times \frac{1.609 \text{ km}}{1 \text{ mi}} = 6\underline{3}.75 = 64 \text{ km/h}$

c. $\dfrac{832 \text{ mi}}{31 \text{ gal}} \times \dfrac{1.609 \text{ km}}{1 \text{ mi}} \times \dfrac{1 \text{ gal}}{4 \text{ qt}} \times \dfrac{1 \text{ qt}}{0.9464 \text{ L}} = 1\underline{1}.41 \text{ km/L} = 11 \text{ km/L}$

1.151 Here it is necessary to convert the data into comparable units, mL for example. Converting 0.100 qt to mL gives (0.100 qt = 0.106 L) 106 mL. Next, using the density relationship, and the fact that 1 mL = 1 cm^3, 50.0 g of Pb corresponds to 4.42 mL Pb. The last quantity is first converted to gram mass units, and then to mL using the density relationship. In this case 0.0250 lb = 11.3 g Pb = 1.00 cm^3 = 1.00 mL Pb. Thus, ranking from smallest volume to greatest:

0.0250 lb Pb (or 1.00 mL) < 50.0 g Pb (or 4.42 mL) < 50.0 mL Pb < 0.100 qt Pb (or 106 mL)

1.152. $7.6 \text{ x } 10^8 \text{ L} \times \dfrac{10^3 \text{ mL}}{1 \text{ L}} \times \dfrac{1 \text{ cm}^3}{1 \text{ mL}} \times \left(\dfrac{1 \text{ in}}{2.54 \text{ cm}}\right)^3 \times \left(\dfrac{1 \text{ ft}}{12 \text{ in}}\right)^3 = 2.\underline{6}84 \times 10^7 = 2.7 \times 10^7 \text{ ft}^3$

1.153. $2 \text{ converters} \times \dfrac{5.0 \text{ x } 10^3 \text{ beads}}{\text{converter}} \times \dfrac{1.0 \text{ x } 10^6 \text{ cm}^2}{\text{bead}} \times \left(\dfrac{1 \text{ m}}{100 \text{ cm}}\right)^2 \times \left(\dfrac{1 \text{ km}}{10^3 \text{ m}}\right)^2 = 1.\underline{00} = 1.0 \text{ km}^2$

1.154. First convert 200.0 mL to m^3 : $200.0 \text{ mL} \times \dfrac{1 \text{ cm}^3}{1 \text{ mL}} \times \left(\dfrac{10^{-2} \text{ m}}{1 \text{ cm}}\right)^3 = 2.000 \times 10^{-4} \text{ m}^3$

Mass does not depend on temperature like volume does. However, if the mass is determined at 20 ºC using the density at 20 ºC, i.e., $m = d_{20} \, x \, V_{20}$,the volume of the water at 80 ºC can be calculated using $V_{80} = \dfrac{m}{d_{80}}$

$$m = d_{20} \times V_{20} = \frac{998 \text{ kg}}{\text{m}^3} \, x \; 2.000 \times 10^{-4} \text{ m}^3 = 0.19\underline{9}6 \text{ kg}$$

$V_{80} = \dfrac{m}{d_{80}} = \dfrac{0.1996 \text{ kg}}{972 \text{ kg/m}^3} \times \dfrac{200.0 \text{ mL}}{2.000 \text{ x } 10^{-4} \text{ m}^3} = 20\underline{5}.3 \text{ mL} = 205 \text{ mL}$ (as expected, an expansion with increasing temperature is noted here).

Because water is more dense at 20 ºC than at 80 ºC, 1.0 L of water will contain more mass of water at the lower temperature, i.e., 998 g vs. 972 g. Since the number of molecules of water is directly proportional to mass, the 1.0 L of water at 20 ºC contains more water molecules.

1.155. $47.0 \text{ cm}^3 \times \dfrac{1025 \text{ kg}}{\text{m}^3} \times \left(\dfrac{10^{-2} \text{ m}}{1 \text{ cm}}\right)^3 \times \dfrac{1000 \text{ g}}{1 \text{ kg}} = 48.\underline{1}8 = 48.2$ g sample of ocean water originally

Assuming a density of 1.0 g/mL for the evaporated water, and recognizing the equivalency between cm^3 and mL units, when 4.1 mL of water evaporates, the sample loses 4.1 g in mass and 4.1 cm^3 in volume. The density of the partially evaporated ocean water sample is obtained by dividing the remaining mass (48.2 g – 4.1 g = 44.1 g) by the remaining volume (47.0 cm^3 – 4.1 cm^3 = 42.9 cm^3).

$$d = \frac{mass}{volume} = \frac{44.1 \text{ g}}{42.9 \text{ cm}^3} = 1.03 \text{ g/cm}^3 \left(= \frac{1030 \text{ kg}}{\text{m}^3}\right)$$

As one would expect, the remaining salt solution is now slightly more dense than the original ocean water sample.

1.156. First, recognizing 5.5 mL = 5.5 cm^3 , determine the mass of liquid gas present.

Mass = d x V = 0.75 g/cm^3 x 5.5 cm^3 = 4.13 g

Next, use the density formula to determine the density of the vaporized gas.

$$d = \frac{mass}{volume} = \frac{4.13\text{ g}}{3.00\text{ L}} = 1.\underline{3}75 = 1.4\text{ g/L, or } 1.4 \times 10^{-3}\text{ g/mL (or g/cm}^3)$$

1.157. a. Since there is the same number of atoms of the gas in each container, the mass is the same in each container.

b. Since $d = m/V$, for the same mass, when the volume is smaller, the density is greater. Since the volume is less in container A, the density is greater.

c. If the volume of container A was doubled, the density would decrease and become equal to the density in container B

1.158. a. $$d = \frac{m}{V} = \frac{39.45\text{ g}}{(3.50\text{ cm})^3} = 0.92\underline{0}11 = 0.920\text{ g/cm}^3$$

b. $$\frac{400.4\text{ mL}}{1} \times \frac{1\text{ cm}^3}{1\text{ mL}} \times \frac{39.45\text{ g}}{(3.50\text{ cm})^3} = 36\underline{8}.41 = 368\text{ g}$$

1.159. $$\frac{300\text{ million people}}{1} \times \frac{1 \times 10^{10}\text{ miles}}{1\text{ person}} \times \frac{1.609\text{ km}}{1\text{ mi}} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ lightyear}}{9.46 \times 10^{15}\text{ m}}$$

$$= \underline{5}.102 \times 10^5 = 5 \times 10^5\text{ lightyears}$$

1.160. $$\frac{1.31\text{ g}}{1\text{ bucket}} \times \frac{1\text{ bucket}}{4.67\text{ L}} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{1\text{ mL}}{1\text{ cm}^3} \times \left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^3 \times \left(\frac{12\text{ in}}{1\text{ ft}}\right)^3$$

$$\times \frac{2.38 \times 10^3\text{ ft}^3}{1} = 1.8\underline{9}04 \times 10^4\text{ g} = 1.89 \times 10^4\text{ g}$$

1.161. a. Since $d = m/V$, an increased mass for the same volume means a higher density for the solution.

b. There would be less water for the same mass of salt. Since the salt is more dense than water, the density would be higher than in part a.

c. Since there would be a greater volume of water for the same mass of salt, the density would be lower than in part a.

1.162. The water will have a lower density than the salt solution. It will not conduct electricity. It will have different chemical properties, such as reaction with silver nitrate solution; and different physical properties, such as the boiling point. Also, you could boil away the water from the salt solution and recover the salt.

■ SOLUTIONS TO CAPSTONE PROBLEMS

1.163. The mass of hydrochloric acid is obtained from the density and the volume.

$$\text{Mass} = \text{density x volume} = 1.096 \text{ g/mL} \times 54.3 \text{ mL} = 59.\underline{5}1 \text{ g}$$

Next, from the law of conservation of mass,

Mass of marble + mass of acid = mass of solution + mass of carbon dioxide gas

Plugging in gives

$$11.1 \text{ g} + 59.\underline{5}1 \text{ g} = 65.7 \text{ g} + \text{mass of carbon dioxide gas}$$

$$\text{Mass of carbon dioxide gas} = 11.1 \text{ g} + 59.\underline{5}1 \text{ g} - 65.7 \text{ g} = 4.\underline{9}1 \text{ g}$$

Finally, use the density to convert the mass of carbon dioxide gas to volume.

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{4.\underline{9}1 \text{ g}}{1.798 \text{ g/ L}} = 2.\underline{7}31 \text{ L} = 2.7 \text{ L}$$

1.164. The mass of sulfuric acid is obtained from the density and the volume.

$$\text{Mass} = \text{density x volume} = 1.153 \text{ g/mL} \times 50.0 \text{ mL} = 57.\underline{6}5 \text{ g}$$

Next, from the law of conservation of mass,

Mass of ore + mass of acid = mass of solution + mass of hydrogen sulfide gas

Plugging in gives

$$10.8 \text{ g} + 57.\underline{6}5 \text{ g} = 65.1 \text{ g} + \text{mass of hydrogen sulfide gas}$$

$$\text{Mass of hydrogen sulfide gas} = 10.8 \text{ g} + 57.\underline{6}5 \text{ g} - 65.1 \text{ g} = 3.\underline{3}5 \text{ g}$$

Finally, use the density to convert the mass of hydrogen sulfide gas to volume.

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{3.\underline{3}5 \text{ g}}{1.393 \text{ g/ L}} = 2.\underline{4}0 \text{ L} = 2.4 \text{ L}$$

1.165. First, calculate the volume of the steel sphere.

$$V = (4/3)\pi r^3 = (4/3)\pi \times (1.58 \text{ in})^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = 27\underline{0}.7 \text{ cm}^3$$

Next, determine the mass of the sphere using the density.

$$\text{Mass} = \text{density x volume} = 7.88 \text{ g/cm}^3 \times 27\underline{0}.7 \text{ cm}^3 = 21\underline{3}3 \text{ g} = 2.13 \times 10^3 \text{ g}$$

1.166. First, calculate the volume of the balloon. Note that the radius is one-half the diameter, or 1.75 ft.

$$V = (4/3)\pi r^3 = (4/3)\pi \text{ x } (1.75 \text{ ft})^3 \times \left(\frac{12 \text{ in}}{1 \text{ ft}}\right)^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 \times \frac{1 \text{ L}}{10^3 \text{ cm}^3} = 63\underline{5}.7 \text{ L}$$

Next, determine the mass of the helium using the density.

$$\text{Mass} = \text{density} \times \text{volume} = 0.166 \text{ g/L} \times 63\underline{5}.7 \text{ L} = 10\underline{5}.5 \text{ g} = 106 \text{ g}$$

1.167. The area of the ice is 840,000 mi^2 − 132,000 mi^2 = 70$\underline{8}$,000 mi^2. Now, determine the volume of this ice.

Volume = area × thickness

$$= 70\underline{8}{,}000\text{ mi}^2 \times \underline{5}000\text{ ft} \times \left(\frac{5280\text{ ft}}{1\text{ mi}}\right)^2 \times \left(\frac{12\text{ in}}{1\text{ ft}}\right)^3 \times \left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^3$$

$$= \underline{2}.794 \times 10^{21}\text{ cm}^3$$

Now use the density to determine the mass of the ice.

$$\text{Mass} = \text{density x volume} = 0.917\text{ g/cm}^3 \times \underline{2}.794 \times 10^{21}\text{ cm}^3 = \underline{2}.56 \times 10^{21}\text{ g} = 3 \times 10^{21}\text{ g}$$

1.168. The height of the ice is 7500 ft − 1500 ft = 6$\underline{0}$00 ft. Now, determine the volume of the ice.

Volume = area × thickness

$$= 5{,}\underline{5}00{,}000\text{ mi}^2 \times 6\underline{0}00\text{ ft} \times \left(\frac{5280\text{ ft}}{1\text{ mi}}\right)^2 \times \left(\frac{12\text{ in}}{1\text{ ft}}\right)^3 \times \left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^3$$

$$= 2.\underline{6}05 \times 10^{22}\text{ cm}^3$$

Now use the density to determine the mass of the ice.

$$\text{Mass} = \text{density} \times \text{volume} = 0.917\text{ g/cm}^3 \times 2.\underline{6}05 \times 10^{22}\text{ cm}^3 = 2.\underline{3}8 \times 10^{22}\text{ g} = 2.4 \times 10^{22}\text{ g}$$

1.169. Let x = mass of ethanol and y = mass of water. Then, use the total mass to write $x + y = 49.6$ g, or $y = 49.6\text{ g} - x$. Thus, the mass of water is 49.6 g − x. Next,

Total volume = volume of ethanol + volume of water

Since the volume is equal to the mass divided by density, you can write

$$\text{Total volume} = \frac{\text{mass of ethanol}}{\text{density of ethanol}} + \frac{\text{mass of water}}{\text{density of water}}$$

Substitute in the known and unknown values to get an equation for x.

$$54.2\text{ cm}^3 = \frac{x}{0.789\text{ g/cm}^3} + \frac{49.6\text{ g} - x}{0.998\text{ g/cm}^3}$$

Multiply both sides of this equation by (0.789)(0.998). Also, multiply both sides by g/cm^3 to simplify the units. This gives the following equation to solve for x.

$$(0.789)(0.998)(54.2)\text{ g} = (0.998)\,x + (0.789)(49.6\text{ g} - x)$$

$$42.\underline{6}78\text{ g} = 0.998\,x + 39.\underline{1}34\text{ g} - 0.789\,x$$

$$0.209\,x = 3.\underline{5}44\text{ g}$$

$$x = \text{mass of ethanol} = 1\underline{6}.95\text{ g}$$

The percentage of ethanol (by mass) in the solution can now be calculated.

$$\text{Percent (mass)} = \frac{\text{mass of ethanol}}{\text{mass of solution}} \times 100\% = \frac{1\underline{6}.95\text{ g}}{49.6\text{ g}} \times 100\% = 3\underline{4}.1\% = 34\%$$

To determine the proof, you must first find the percentage by volume of ethanol in the solution. The volume of ethanol is obtained using the mass and the density.

$$\text{Volume} = \frac{\text{mass of ethanol}}{\text{density of ethanol}} = \frac{1\underline{6}.95\text{ g}}{0.789\text{ g/ cm}^3} = 2\underline{1}.48\text{ cm}^3$$

The percentage of ethanol (by volume) in the solution can now be calculated.

$$\text{Percent (volume)} = \frac{\text{volume of ethanol}}{\text{volume of solution}} \times 100\% = \frac{2\underline{1}.48\text{ cm}^3}{54.2\text{ cm}^3} \times 100\% = 3\underline{9}.63\%$$

The proof can now be calculated.

$$\text{Proof} = 2 \times \text{Percent (volume)} = 2 \times 3\underline{9}.63 = 7\underline{9}.27 = 79\text{ proof}$$

1.170. Let x = mass of gold and y = mass of silver. Then, use the total mass to write $x + y = 9.35$ g, or $y = 9.35\text{ g} - x$. Thus, the mass of silver is $9.35\text{ g} - x$. Next,

Total volume = volume of gold + volume of silver

Since the volume is equal to the mass divided by density, you can write

$$\text{Total volume} = \frac{\text{mass of gold}}{\text{density of gold}} + \frac{\text{mass of silver}}{\text{density of silver}}$$

Substitute in the known and unknown values to get an equation for x.

$$0.654\text{ cm}^3 = \frac{x}{19.3\text{ g/cm}^3} + \frac{9.35\text{ g} - x}{10.5\text{ g/cm}^3}$$

Multiply both sides of this equation by (19.3)(10.5). Also multiply both sides by g/cm^3 to simplify the units. This gives the following equation to solve for x.

$$(19.3)(10.5)(0.654)\text{ g} = (10.5)\,x + (19.3)(9.35\text{ g} - x)$$

$$13\underline{2}.53\text{ g} = 10.5\,x + 18\underline{0}.45\text{ g} - 19.3\,x$$

$$8.8\,x = 4\underline{7}.92\text{ g}$$

$$x = \text{mass of gold} = 5.\underline{4}45\text{ g}$$

The percentage of gold (by mass) in the solution can now be calculated.

$$\text{Percent (mass)} = \frac{\text{mass of gold}}{\text{mass of jewlrey}} \times 100\% = \frac{5.\underline{4}45\text{ g}}{9.35\text{ g}} \times 100\% = 5\underline{8}.2\% = 58\%$$

The relative amount of gold in the alloy can now be calculated. The fraction of gold in the alloy is 58.2% / 100% = 0.582. Thus,

$$\text{Proportion of gold} = 24\text{ karats x } 0.5\underline{8}2 = 1\underline{3}.9\text{ karats} = 14\text{ karats}$$

1.171. The volume of the mineral can be obtained from the mass difference between the water displaced and the air displaced, and the densities of water and air.

Mass difference = 18.49 g − 16.21 g = 2.28 g

$$\text{Volume of mineral} = \frac{\text{mass difference}}{\text{density of water} - \text{density of air}}$$

$$= \frac{2.28\text{ g}}{0.9982\text{ g/cm}^3 - 1.205 \times 10^{-3}\text{ g/cm}^3} = 2.2\underline{8}6\text{ cm}^3$$

The mass of the mineral is equal to its mass in air plus the weight of the displaced air. The weight of the displaced air is obtained from the volume of the mineral and the density of air.

Mass of displaced air = density x volume

$$= 1.205 \text{ g/L x } 2.2\underline{8}6 \text{ cm}^3 \times \frac{1 \text{ L}}{10^3 \text{ cm}^3} = 2.7\underline{5}5 \times 10^{-3} \text{ g}$$

Mass of mineral = 18.49 g + 2.7$\underline{5}$5 × 10^{-3} g = 18.4$\underline{9}$27 g

The density of the mineral can now be calculated.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{18.4\underline{9}27 \text{ g}}{2.2\underline{8}6 \text{ cm}^3} = 8.0\underline{8}9 \text{ g/cm}^3 = 8.09 \text{ g/cm}^3$$

1.172. The volume of the mineral can be obtained from the mass of the water displaced and the density of water.

Mass difference = 7.35 g − 5.40 g = 1.95 g

$$\text{Volume of mineral} = \frac{\text{mass difference}}{\text{density of water} - \text{density of air}}$$

$$\text{Volume of mineral} = \frac{1.95 \text{ g}}{0.9982 \text{ g/cm}^3 - 1.205 \text{ x } 10^{-3} \text{ g/cm}^3} = 1.9\underline{5}5 \text{ cm}^3$$

The mass of the mineral is equal to its mass in air plus the weight of the displaced air. The weight of the displaced air is obtained from the volume of the mineral and the density of air.

Mass of displaced air = density x volume

$$= 1.205 \text{ g/L x } 1.9\underline{5}5 \text{ cm}^3 \times \frac{1 \text{ L}}{10^3 \text{ cm}^3} = 2.3\underline{5}6 \times 10^{-3} \text{ g}$$

Mass of mineral = 7.35 g + 2.3$\underline{5}$6 × 10^{-3} g = 7.3$\underline{5}$2 g

The density of the mineral can now be calculated.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{7.3\underline{5}2 \text{ g}}{1.9\underline{5}5 \text{ cm}^3} = 3.7\underline{6}0 \text{ g/cm}^3 = 3.76 \text{ g/cm}^3$$

1.173. The volume of the object can be obtained from the mass of the ethanol displaced and the density of ethanol.

Mass of ethanol displaced = 15.8 g − 10.5 g = 5.3 g

$$\text{Volume of object} = \frac{\text{mass of ethanol}}{\text{density of ethanol}} = \frac{5.3 \text{ g}}{0.789 \text{ g/ cm}^3} = 6.\underline{7}17 \text{ cm}^3$$

The density of the object can now be calculated.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{15.8 \text{ g}}{6.\underline{7}17 \text{ cm}^3} = 2.\underline{3}52 \text{ g/cm}^3 = 2.4 \text{ g/cm}^3$$

1.174. The volume of the metal can be obtained from the mass of the mercury displaced and the density of mercury.

Mass of mercury displaced = 255 g − 101 g = 154 g

$$\text{Volume of object} = \frac{\text{mass of mercury}}{\text{density of mercury}} = \frac{154\text{ g}}{13.6\text{ g/cm}^3} = 11.\underline{3}23\text{ cm}^3$$

The density of the metal can now be calculated.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{255\text{ g}}{11.\underline{3}23\text{ cm}^3} = 22.\underline{5}1\text{ g/cm}^3 = 22.5\text{ g/cm}^3$$

1.175. The first set of measurements, although quite close to each other, yields an average that is significantly and consistently higher than the expected outcome. Thus, it is precise but inaccurate. A systematic error is likely present that could be corrected to yield a more favorable outcome.

The second set yields an average that is quite close to the expected outcome, thus it is accurate. However, the precision of the data is relatively poor compared to the data sets 1 and 3.

The third set results in an average that is quite close to the expected outcome with each measurement very close to one another. It would be described as both accurate and precise, and the most favorable outcome of all the sets.

The last data set gives an average that is significantly higher than the expected outcome. Compared to data sets 1 and 3, the precision is also very poor. It would be described as inaccurate and imprecise, and the least favorable outcome of all the sets.

The following table summarizes these arguments:

Data	Accurate?	Precise?
38.74, 38.75, 38.76	No	Yes
37.15, 37.44, 37.75	Yes	No
37.44, 37.46, 37.48	Yes	Yes
39.43, 37.45, 38.64	No	No

1.176. The first data set gives an average that is quite close to the expected outcome with each measurement very close to one another. It would be described as both accurate and precise, and the most favorable outcome of all the sets.

The second data set yields an average that is quite close to the expected outcome, thus it is accurate. However, the precision of the data is relatively poor compared to the data sets 1 and 3.

The third set of measurements, although quite close to each other, yields an average that is significantly and consistently lower than the expected outcome. Thus, the data has precision but is inaccurate. A systematic error is likely present that could be corrected to yield a more favorable outcome.

The last data set gives an average that is significantly lower than the expected outcome. Compared to the first and third sets of data, the precision is also very poor. It would be described as inaccurate and imprecise, and the least favorable outcome of all the sets.

The following table summarizes these arguments:

Data	Precise?	Accurate?
32.00, 32.01, 31.99	Yes	Yes
29.50, 32.00, 34.50	No	Yes
29.00, 29.01, 29.02	Yes	No
25.00, 27.00, 29.00	No	No

1.177. (a) For the moment, assume the liquid to be water. Multiplying the volume in gallons by the density in lbs/gal and then converting to kg would give the mass of the water in kg as follows:

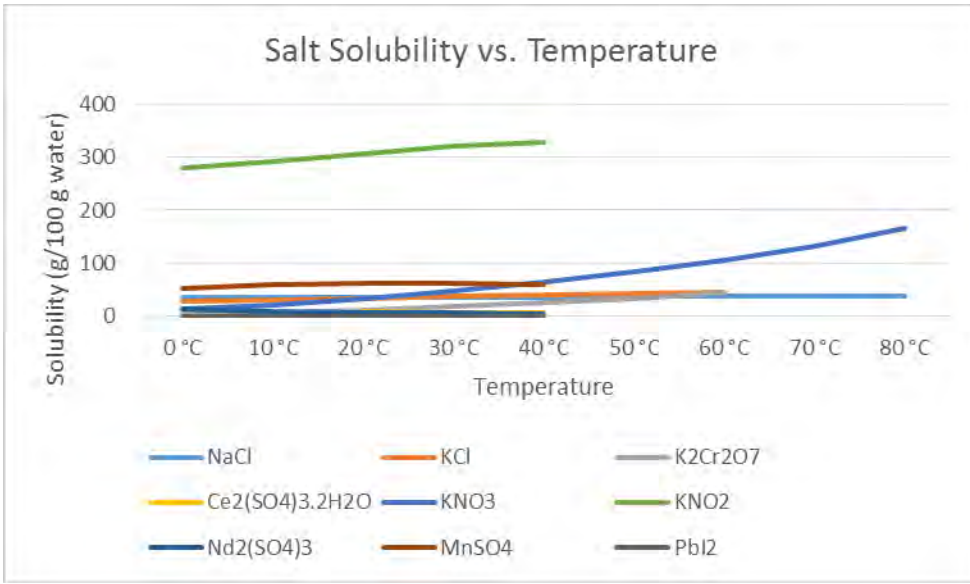
$$m_{H_2O} = V_{H_2O} \text{ x } d_{H_2O} = (24{,}500 \text{ gal}) \text{ x } (\frac{8.35 \text{ lb}}{\text{gal}}) \text{ x } (\frac{1 \text{ kg}}{2.205 \text{ lb}}) = 9.2\underline{7}8 \text{ x } 10^4 \text{ kg}$$

Since the liquid in the barge is denser than pure water by a factor of 1.01, the mass of liquid being carried is obtained by multiplying the calculated mass of water by the specific gravity of the liquid, i.e.,

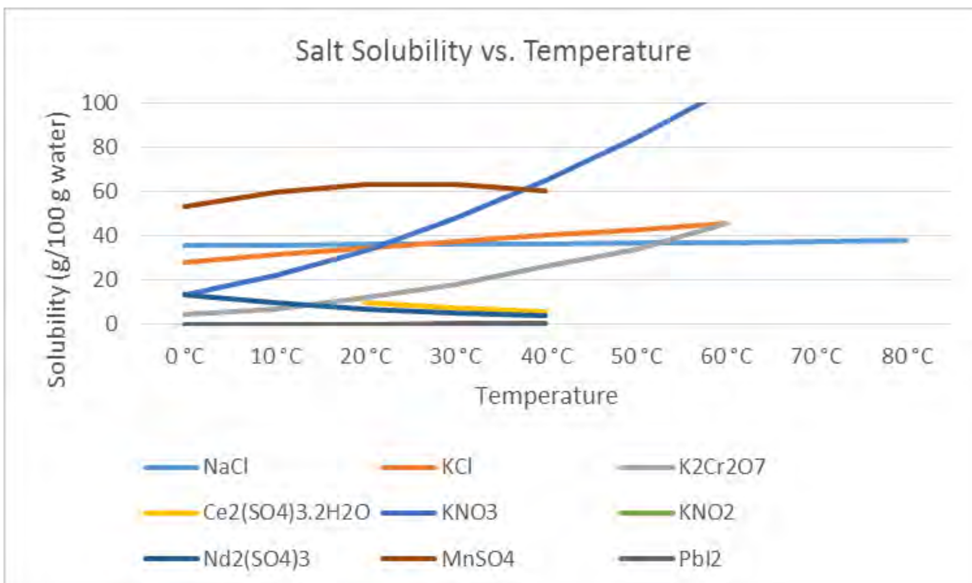
$$m_{liquid} = 1.01 \text{ x } m_{H_2O} = 1.01 \text{ x } 9.2\underline{7}8 \text{ x } 10^4 \text{ kg} = 9.3\underline{7}1 \text{ x } 10^4 \text{ kg} = 9.37 \text{ x } 10^4 \text{ kg}$$

(b) Water bodies at river mouths that are adjacent to the ocean have specific gravities very close to that of average seawater (specific gravity = 1.03); hence, the barge's liquid is less dense than the surrounding water. Considering the leaked liquid does not mix well with the surrounding seawater, the less dense liquid would float on the seawater. Thus, assuming weather conditions do not serious work to disperse the spill, surface booms would likely be effective tools in cleanup efforts.

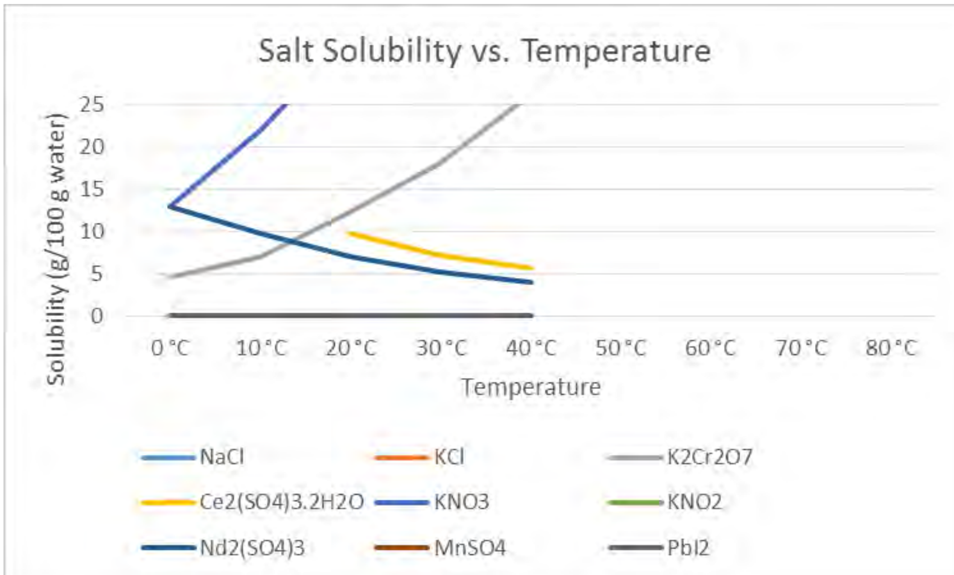
1.178. Step 1: Graph using complete data set



Step 2: Graph from Step 1 scaled to a maximum of 100 g/100 g H_2O



Step 3: Graph from Step 1 scaled to a maximum of 25 g/100 g H_2O



Step 4:

(a) Those salts which exhibit an increasing trend in solubility as the temperature increases include NaCl, KCl, $K_2Cr_2O_7$, KNO_3, KNO_2, and PbI_2.

(b) Those salts which exhibit a decreasing trend in solubility as the temperature increases include $Ce_2(SO_4)_3 \cdot 2H_2O$ and $Nd_2(SO_4)_3$.

(c) $MnSO_4$ initially exhibits a slight increase in solubility as the temperature increases but reverses this trend above 20ºC. It is also noted that NaCl and PbI_2 do not exhibit substantial increases over the temperature range of the data.

Step 5:

(a) Reasonable estimates (to 2 significant figures) of the requested solubility values would be as follows:

solubility of $Ce_2(SO_4)_3 \cdot 2H_2O$ at 10ºC : 16 g / 100 g H_2O
solubility of $Ce_2(SO_4)_3 \cdot 2H_2O$ at 50ºC : 4.8 g / 100 g H_2O
solubility of KNO_2 at 50ºC : 340 g / 100 g H_2O

(b) The only salt that would likely be considered insoluble in the current context would be PbI_2.