

Summer Assignment AP Chemistry

Hello AP Chemistry! I look forward to beginning our journey together this fall. For your summer assignment, I would like you to refresh yourself on the topics of significant figures, nomenclature, and stoichiometry. There will be a test on Stoichiometry on September 18th.

Below I have attached problems from the textbook that you will be receiving this fall: *Chemistry Tenth Edition* by Zumdahl, Zumdahl and DeCoste

I would like you to do the following problems:

pages 32-34h; # 4, 5, 15, 16, 28, 33, 35, 37, 39, 45, 75, 83

pages 65-67h; 32, 36, 42, 46, 71, 73, 75, 79, 81, 83,

pages 112-115j; # 3, 27, 31, 39, 43, 65, 69, 79, 91, 93, 111, 132, 135, 138, 160

Please be sure that you are doing the correct problems on the correct pages by checking the page numbers in the corner of the scan.

These problems could take a while, so please plan accordingly and do not save it all for the last few days of summer.

If you find that there are problems you cannot do, start by investigating the topics online. You can also email me at mhammond@eustace.org if you would like me to send you copies of the Honors Chemistry slides to study with. I am also available in the month of August for Google Meetings if you would like one-on-one help with the more difficult problems.

However, it is very important to have this completed by the **First Day** of class, because more homework will be assigned then and I do not want anyone to fall behind. This summer work **will be graded** for a mix of completion and correctness.

Best of luck and I cannot wait to meet everyone!

-Dr. Hammond

- c. The marble weighs more than an equivalent volume of the water.
- d. The force from dropping the marble breaks the surface tension of the water.
- e. The marble has greater mass and volume than the water. Justify your choice, and for choices you did not pick, explain what is wrong about them.
4. You have two beakers, one filled to the 100-mL mark with sugar (the sugar has a mass of 180.0 g) and the other filled to the 100-mL mark with water (the water has a mass of 100.0 g). You pour all the sugar and all the water together in a bigger beaker and stir until the sugar is completely dissolved.
- a. Which of the following is true about the mass of the solution? Explain.
- It is much greater than 280.0 g.
 - It is somewhat greater than 280.0 g.
 - It is exactly 280.0 g.
 - It is somewhat less than 280.0 g.
 - It is much less than 280.0 g.
- b. Which of the following is true about the volume of the solution? Explain.
- It is much greater than 200.0 mL.
 - It is somewhat greater than 200.0 mL.
 - It is exactly 200.0 mL.
 - It is somewhat less than 200.0 mL.
 - It is much less than 200.0 mL.
5. You may have noticed that when water boils, you can see bubbles that rise to the surface of the water.
- a. What is inside these bubbles?
- air
 - hydrogen and oxygen gas
 - oxygen gas
 - water vapor
 - carbon dioxide gas
- b. Is the boiling of water a chemical or physical change? Explain.
6. If you place a glass rod over a burning candle, the glass appears to turn black. What is happening to each of the following (physical change, chemical change, both, or neither) as the candle burns? Explain each answer.
- a. the wax b. the wick c. the glass rod
7. Which characteristics of a solid, a liquid, and a gas are exhibited by each of the following substances? How would you classify each substance?
- a. a bowl of pudding b. a bucketful of sand
8. Sketch a magnified view (showing atoms/molecules) of each of the following and explain:
- a. a heterogeneous mixture of two different compounds
- b. a homogeneous mixture of an element and a compound
9. Paracelsus, a sixteenth-century alchemist and healer, adopted as his slogan: "The patients are your textbook, the sickbed is your study." Is this view consistent with using the scientific method?
10. What is wrong with the following statement?
"The results of the experiment do not agree with the theory. Something must be wrong with the experiment."
11. Why is it incorrect to say that the results of a measurement were accurate but not precise?
12. What data would you need to estimate the money you would spend on gasoline to drive your car from New York to Chicago? Provide estimates of values and a sample calculation.
13. Sketch two pieces of glassware: one that can measure volume to the thousandths place and one that can measure volume only to the ones place.
14. You have a 1.0-cm³ sample of lead and a 1.0-cm³ sample of glass. You drop each in separate beakers of water. How do the volumes of water displaced by each sample compare? Explain.
15. Consider the addition of 15.4 to 28. What would a mathematician say the answer is? What would a scientist say? Justify the scientist's answer, not merely citing the rule, but explaining it.
16. Consider multiplying 26.2 by 16.43. What would a mathematician say the answer is? What would a scientist say? Justify the scientist's answer, not merely citing the rule, but explaining it.
17. True or false? For mathematical operation performed on two measurements, the number of significant figures in the answer is the same as the least number of significant figures in either of the measurements. Explain your answer.
18. Is there a difference between a homogeneous mixture of hydrogen and oxygen in a 2:1 ratio and a sample of water vapor? Explain.

A blue question or exercise number indicates that the answer to that question or exercise appears at the back of this book and a solution appears in the *Solutions Guide*, as found on the Instructor Companion Site.

Questions

19. The difference between a *law* and a *theory* is the difference between *what* and *why*. Explain.
20. The scientific method is a dynamic process. What does this mean?
21. Explain the fundamental steps of the scientific method.
22. What is the difference between random error and systematic error?
23. A measurement is a quantitative observation involving both a number and a unit. What is a qualitative observation? What are the SI units for mass, length, and volume? What is the assumed uncertainty in a number (unless stated otherwise)? The uncertainty of a measurement depends on the precision of the measuring device. Explain.
24. To determine the volume of a cube, a student measured one of the dimensions of the cube several times. If the true dimension of the cube is 10.62 cm, give an example of four sets of measurements that would illustrate the following.
- imprecise and inaccurate data
 - precise but inaccurate data
 - precise and accurate data
- Give a possible explanation as to why data can be imprecise or inaccurate. What is wrong with saying a set of measurements is imprecise but accurate?

25. What are significant figures? Show how to indicate the number one thousand to 1 significant figure, 2 significant figures, 3 significant figures, and 4 significant figures. Why is the answer, to the correct number of significant figures, not 1.0 for the following calculation?

$$\frac{1.5 - 1.0}{0.50} =$$

26. A cold front moves through and the temperature drops by 20 degrees. In which temperature scale would this 20 degree change represent the largest change in temperature?
27. When the temperature in degrees Fahrenheit (T_F) is plotted vs. the temperature in degrees Celsius (T_C), a straight-line plot results. A straight-line plot also results when T_C is plotted vs. T_K (the temperature in kelvins). Reference Appendix A1.3 and determine the slope and y-intercept of each of these two plots.
28. In a multiple-step calculation, is it better to round off the numbers to the correct number of significant figures in each step of the calculation or to round off only the final answer?
29. Is the density of a gaseous substance larger or smaller than the density of a liquid or a solid at the same temperature? Why?
30. Give four examples illustrating each of the following terms.
- | | |
|--------------------------|--------------------|
| a. homogeneous mixture | d. element |
| b. heterogeneous mixture | e. physical change |
| c. compound | f. chemical change |

Exercises

In this section similar exercises are paired.

Significant Figures and Unit Conversions

31. Which of the following are exact numbers?
- There are 100 cm in 1 m.
 - One meter equals 1.094 yards.
 - We can use the equation $^{\circ}\text{F} = \frac{9}{5}^{\circ}\text{C} + 32$ to convert from Celsius to Fahrenheit temperature. Are the numbers $\frac{9}{5}$ and 32 exact or inexact?
 - $\pi = 3.1415927$.
32. Indicate the number of significant figures in each of the following:
- This book contains more than 1000 pages.
 - A mile is about 5300 ft.
 - A liter is equivalent to 1.059 qt.
 - The population of the United States is approaching 3.1×10^2 million.
 - A kilogram is 1000 g.
 - The Boeing 747 cruises at around 600 mi/h.
33. How many significant figures are there in each of the following values?
- | | |
|---------------------------|-------------|
| a. 6.07×10^{-15} | e. 463.8052 |
| b. 0.003840 | f. 300 |
| c. 17.00 | g. 301 |
| d. 8×10^8 | h. 300. |

34. How many significant figures are in each of the following?

- | | |
|-----------------------|---------------------------|
| a. 100 | e. 0.0048 |
| b. 1.0×10^2 | f. 0.00480 |
| c. 1.00×10^3 | g. 4.80×10^{-3} |
| d. 100. | h. 4.800×10^{-3} |

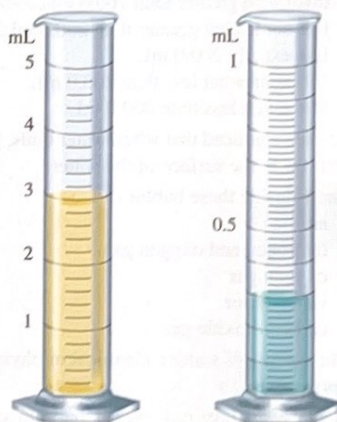
35. Round off each of the following numbers to the indicated number of significant digits, and write the answer in standard scientific notation.

- 0.00034159 to three digits
- 103.351×10^2 to four digits
- 17.9915 to five digits
- 3.365×10^5 to three digits

36. Use exponential notation to express the number 385,500 to

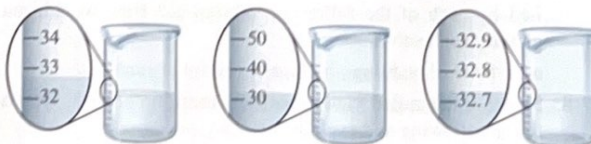
- one significant figure.
- two significant figures.
- three significant figures.
- five significant figures.

37. You have liquid in each graduated cylinder shown:



You then add both samples to a beaker. How would you write the number describing the total volume? What limits the precision of this number?

38. The beakers shown below have different precisions.



- Label the amount of water in each of the three beakers to the correct number of significant figures.
- Is it possible for each of the three beakers to contain the exact same amount of water? If no, why not? If yes, did you report the volumes as the same in part a? Explain.
- Suppose you pour the water from these three beakers into one container. What should be the volume in the container reported to the correct number of significant figures?

39. Evaluate each of the following, and write the answer to the appropriate number of significant figures.
- $212.2 + 26.7 + 402.09$
 - $1.0028 + 0.221 + 0.10337$
 - $52.331 + 26.01 - 0.9981$
 - $2.01 \times 10^2 + 3.014 \times 10^3$
 - $7.255 - 6.8350$
40. Perform the following mathematical operations, and express each result to the correct number of significant figures.
- $\frac{0.102 \times 0.0821 \times 273}{1.01}$
 - $0.14 \times 6.022 \times 10^{23}$
 - $4.0 \times 10^4 \times 5.021 \times 10^{-3} \times 7.34993 \times 10^2$
 - $\frac{2.00 \times 10^6}{3.00 \times 10^{-7}}$
41. Perform the following mathematical operations, and express the result to the correct number of significant figures.
- $\frac{2.526}{3.1} + \frac{0.470}{0.623} + \frac{80.705}{0.4326}$
 - $(6.404 \times 2.91) / (18.7 - 17.1)$
 - $6.071 \times 10^{-5} - 8.2 \times 10^{-6} - 0.521 \times 10^{-4}$
 - $(3.8 \times 10^{-12} + 4.0 \times 10^{-13}) / (4 \times 10^{12} + 6.3 \times 10^{13})$
 - $\frac{9.5 + 4.1 + 2.8 + 3.175}{4}$
(Assume that this operation is taking the average of four numbers. Thus 4 in the denominator is exact.)
 - $\frac{8.925 - 8.905}{8.925} \times 100$
(This type of calculation is done many times in calculating a percentage error. Assume that this example is such a calculation; thus 100 can be considered to be an exact number.)
42. Perform the following mathematical operations, and express the result to the correct number of significant figures.
- $6.022 \times 10^{23} \times 1.05 \times 10^2$
 - $\frac{6.6262 \times 10^{-34} \times 2.998 \times 10^8}{2.54 \times 10^{-9}}$
 - $1.285 \times 10^{-2} + 1.24 \times 10^{-3} + 1.879 \times 10^{-1}$
 - $\frac{(1.00866 - 1.00728)}{6.02205 \times 10^{23}}$
 - $\frac{9.875 \times 10^2 - 9.795 \times 10^2}{9.875 \times 10^2} \times 100$ (100 is exact)
 - $\frac{9.42 \times 10^2 + 8.234 \times 10^2 + 1.625 \times 10^3}{3}$ (3 is exact)
43. Perform each of the following conversions.
- 8.43 cm to millimeters
 - 2.41×10^2 cm to meters
 - 294.5 nm to centimeters
 - 1.445×10^4 m to kilometers
 - 235.3 m to millimeters
 - 903.3 nm to micrometers
44. a. How many kilograms are in 1 teragram?
 b. How many nanometers are in 6.50×10^2 terameters?
 c. How many kilograms are in 25 femtograms?
 d. How many liters are in 8.0 cubic decimeters?
 e. How many microliters are in 1 milliliter?
 f. How many picograms are in 1 microgram?
45. Perform the following unit conversions.
- Congratulations! You and your spouse are the proud parents of a new baby, born while you are studying in a country that uses the metric system. The nurse has informed you that the baby weighs 3.91 kg and measures 51.4 cm. Convert your baby's weight to pounds and ounces and her length to inches (rounded to the nearest quarter inch).
 - The circumference of the earth is 25,000 mi at the equator. What is the circumference in kilometers? in meters?
 - A rectangular solid measures 1.0 m by 5.6 cm by 2.1 dm. Express its volume in cubic meters, liters, cubic inches, and cubic feet.
46. Perform the following unit conversions.
- 908 oz to kilograms
 - 12.8 L to gallons
 - 125 mL to quarts
 - 2.89 gal to milliliters
 - 4.48 lb to grams
 - 550 mL to quarts
47. Use the following exact conversion factors to perform the stated calculations:
- $$5\frac{1}{2} \text{ yd} = 1 \text{ rod}$$
- $$40 \text{ rods} = 1 \text{ furlong}$$
- $$8 \text{ furlongs} = 1 \text{ mile}$$
- The Kentucky Derby race is 1.25 miles. How long is the race in rods, furlongs, meters, and kilometers?
 - A marathon race is 26 miles, 385 yards. What is this distance in rods, furlongs, meters, and kilometers?
48. Although the preferred SI unit of area is the square meter, land is often measured in the metric system in hectares (ha). One hectare is equal to 10,000 m². In the English system, land is often measured in acres (1 acre = 160 rod²). Use the exact conversions and those given in Exercise 47 to calculate the following.
- 1 ha = _____ km²
 - The area of a 5.5-acre plot of land in hectares, square meters, and square kilometers
 - A lot with dimensions 120 ft by 75 ft is to be sold for \$6500. What is the price per acre? What is the price per hectare?

49. Precious metals and gems are measured in troy weights in the English system:

$$\begin{aligned} 24 \text{ grains} &= 1 \text{ pennyweight (exact)} \\ 20 \text{ pennyweight} &= 1 \text{ troy ounce (exact)} \\ 12 \text{ troy ounces} &= 1 \text{ troy pound (exact)} \\ 1 \text{ grain} &= 0.0648 \text{ g} \\ 1 \text{ carat} &= 0.200 \text{ g} \end{aligned}$$

- The most common English unit of mass is the pound avoirdupois. What is 1 troy pound in kilograms and in pounds?
- What is the mass of a troy ounce of gold in grams and in carats?
- The density of gold is 19.3 g/cm^3 . What is the volume of a troy pound of gold?

50. Apothecaries (druggists) use the following set of measures in the English system:

$$\begin{aligned} 20 \text{ grains ap} &= 1 \text{ scruple (exact)} \\ 3 \text{ scruples} &= 1 \text{ dram ap (exact)} \\ 8 \text{ dram ap} &= 1 \text{ oz ap (exact)} \\ 1 \text{ dram ap} &= 3.888 \text{ g} \end{aligned}$$

- Is an apothecary grain the same as a troy grain? (See Exercise 49.)
- 1 oz ap = _____ oz troy.
- An aspirin tablet contains $5.00 \times 10^2 \text{ mg}$ of active ingredient. What mass in grains ap of active ingredient does it contain? What mass in scruples?
- What is the mass of 1 scruple in grams?

51. For a pharmacist dispensing pills or capsules, it is often easier to weigh the medication to be dispensed than to count the individual pills. If a single antibiotic capsule weighs 0.65 g, and a pharmacist weighs out 15.6 g of capsules, how many capsules have been dispensed?

52. A children's pain relief elixir contains 80. mg acetaminophen per 0.50 teaspoon. The dosage recommended for a child who weighs between 24 and 35 lb is 1.5 teaspoons. What is the range of acetaminophen dosages, expressed in mg acetaminophen/kg body weight, for children who weigh between 24 and 35 lb?

53. Science fiction often uses nautical analogies to describe space travel. If the starship *U.S.S. Enterprise* is traveling at warp factor 1.71, what is its speed in knots and in miles per hour? (Warp 1.71 = 5.00 times the speed of light; speed of light = $3.00 \times 10^8 \text{ m/s}$; 1 knot = 2030 yd/h.)

54. The world record for the hundred meter dash is 9.58 s. What is the corresponding average speed in units of m/s, km/h, ft/s, and mi/h? At this speed, how long would it take to run 1.00×10^2 yards?

55. You are driving 65 mi/h and take your eyes off the road for "just a second." What distance (in feet) do you travel in this time?

56. You pass a road sign saying "New York 112 km." If you drive at a constant speed of 65 mi/h, how long should it take you to reach New York? If your car gets 28 miles to the gallon, how many liters of gasoline are necessary to travel 112 km?

57. The dosage for an antibiotic is prescribed at 8.0 mg per kilogram of body weight, taken twice daily for two weeks. What total mass of antibiotic will be taken by a 180-lb person for the two-week period?

58. In recent years, there has been a large push for an increase in the use of renewable resources to produce the energy we need to power our vehicles. One of the newer fuels that has become more widely available is E85, a mixture of 85% ethanol and 15% gasoline. Despite being more environmentally friendly, one of the potential drawbacks of E85 fuel is that it produces less energy than conventional gasoline. Assume a car gets 28.0 mi/gal using gasoline at \$3.50/gal and 22.5 mi/gal using E85 at \$2.85/gal. How much will it cost to drive 500. miles using each fuel?

59. Mercury poisoning is a debilitating disease that is often fatal. In the human body, mercury reacts with essential enzymes leading to irreversible inactivity of these enzymes. If the amount of mercury in a polluted lake is $0.4 \mu\text{g Hg/mL}$, what is the total mass in kilograms of mercury in the lake? (The lake has a surface area of 100 mi^2 and an average depth of 20 ft.)

60. Carbon monoxide (CO) detectors sound an alarm when peak levels of carbon monoxide reach 100 parts per million (ppm). This level roughly corresponds to a composition of air that contains $400,000 \mu\text{g}$ carbon monoxide per cubic meter of air ($400,000 \mu\text{g/m}^3$). Assuming the dimensions of a room are $18 \text{ ft} \times 12 \text{ ft} \times 8 \text{ ft}$, estimate the mass of carbon monoxide in the room that would register 100 ppm on a carbon monoxide detector.

Temperature

61. Convert the following Fahrenheit temperatures to the Celsius and Kelvin scales.

- -459°F , an extremely low temperature
- -40°F , the answer to a trivia question
- 68°F , room temperature
- $7 \times 10^7 \text{ }^\circ\text{F}$, temperature required to initiate fusion reactions in the sun

62. A thermometer gives a reading of $96.1^\circ\text{F} \pm 0.2^\circ\text{F}$. What is the temperature in $^\circ\text{C}$? What is the uncertainty?

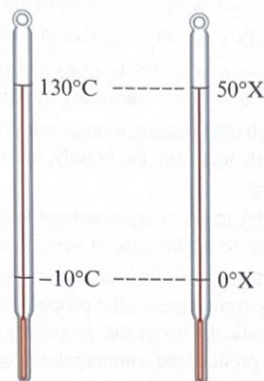
63. Convert the following Celsius temperatures to Kelvin and to Fahrenheit degrees.

- the temperature of someone with a fever, 39.2°C
- a cold wintery day, -25°C
- the lowest possible temperature, -273°C
- the melting-point temperature of sodium chloride, 801°C

64. Convert the following Kelvin temperatures to Celsius and Fahrenheit degrees.

- the temperature that registers the same value on both the Fahrenheit and Celsius scales, 233 K
- the boiling point of helium, 4 K
- the temperature at which many chemical quantities are determined, 298 K
- the melting point of tungsten, 3680 K

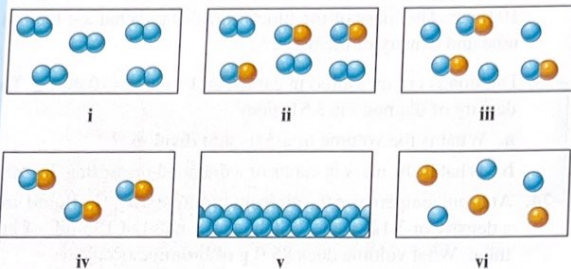
65. At what temperature is the temperature in degrees Fahrenheit equal to twice the temperature in degrees Celsius?
66. The average daytime temperatures on the earth and Jupiter are 72°F and 313 K , respectively. Calculate the difference in temperature, in $^{\circ}\text{C}$, between these two planets.
67. Use the figure below to answer the following questions.



- a. Derive the relationship between $^{\circ}\text{C}$ and $^{\circ}\text{X}$.
- b. If the temperature outside is 22.0°C , what is the temperature in units of $^{\circ}\text{X}$?
- c. Convert 58.0°X to units of $^{\circ}\text{C}$, K , and $^{\circ}\text{F}$.
68. Ethylene glycol is the main component in automobile antifreeze. To monitor the temperature of an auto cooling system, you intend to use a meter that reads from 0 to 100. You devise a new temperature scale based on the approximate melting and boiling points of a typical antifreeze solution (-45°C and 115°C). You wish these points to correspond to 0°A and 100°A , respectively.
- a. Derive an expression for converting between $^{\circ}\text{A}$ and $^{\circ}\text{C}$.
- b. Derive an expression for converting between $^{\circ}\text{F}$ and $^{\circ}\text{A}$.
- c. At what temperature would your thermometer and a Celsius thermometer give the same numerical reading?
- d. Your thermometer reads 86°A . What is the temperature in $^{\circ}\text{C}$ and in $^{\circ}\text{F}$?
- e. What is a temperature of 45°C in $^{\circ}\text{A}$?
- Density**
69. A material will float on the surface of a liquid if the material has a density less than that of the liquid. Given that the density of water is approximately 1.0 g/mL , will a block of material having a volume of $1.2 \times 10^4\text{ in}^3$ and weighing 350 lb float or sink when placed in a reservoir of water?
70. One metal object is a cube with edges of 3.00 cm and a mass of 140.4 g . A second metal object is a sphere with a radius of 1.42 cm and a mass of 61.6 g . Are these objects made of the same or different metals? Assume the calculated densities are accurate to $\pm 1.00\%$.
71. A star is estimated to have a mass of $2 \times 10^{36}\text{ kg}$. Assuming it to be a sphere of average radius $7.0 \times 10^5\text{ km}$, calculate the average density of the star in units of grams per cubic centimeter.
72. A rectangular block has dimensions $2.9\text{ cm} \times 3.5\text{ cm} \times 10.0\text{ cm}$. The mass of the block is 615.0 g . What are the volume and density of the block?
73. Diamonds are measured in carats, and $1\text{ carat} = 0.200\text{ g}$. The density of diamond is 3.51 g/cm^3 .
- a. What is the volume of a 5.0-carat diamond?
- b. What is the mass in carats of a diamond measuring 2.8 mL ?
74. At room temperature the element bromine, Br_2 , is a liquid with a density of 3.12 g/cm^3 . Calculate the mass of 125 mL of bromine. What volume does 85.0 g of bromine occupy?
75. A sample containing 33.42 g of metal pellets is poured into a graduated cylinder initially containing 12.7 mL of water, causing the water level in the cylinder to rise to 21.6 mL . Calculate the density of the metal.
76. The density of pure silver is 10.5 g/cm^3 at 20°C . If 5.25 g of pure silver pellets is added to a graduated cylinder containing 11.2 mL of water, to what volume level will the water in the cylinder rise?
77. In each of the following pairs, which has the greater mass? (See Table 1.5.)
- a. 1.0 kg of feathers or 1.0 kg of lead
- b. 1.0 mL of mercury or 1.0 mL of water
- c. 19.3 mL of water or 1.00 mL of gold
- d. 75 mL of copper or 1.0 L of benzene
78. a. Calculate the mass of ethanol in 1.50 qt of ethanol. (See Table 1.5.)
- b. Calculate the mass of mercury in 3.5 in^3 of mercury. (See Table 1.5.)
79. In each of the following pairs, which has the greater volume?
- a. 1.0 kg of feathers or 1.0 kg of lead
- b. 100 g of gold or 100 g of water
- c. 1.0 L of copper or 1.0 L of mercury
80. Using Table 1.5, calculate the volume of 25.0 g of each of the following substances at 1 atm .
- a. hydrogen gas
- b. water
- c. iron
- Chapter 5 discusses the properties of gases. One property unique to gases is that they contain mostly empty space. Explain using the results of your calculations.
81. The density of osmium (the densest metal) is 22.57 g/cm^3 . If a 1.00-kg rectangular block of osmium has two dimensions of $4.00\text{ cm} \times 4.00\text{ cm}$, calculate the third dimension of the block.
82. A copper wire (density = 8.96 g/cm^3) has a diameter of 0.25 mm . If a sample of this copper wire has a mass of 22 g , how long is the wire?

Classification and Separation of Matter

83. Match each description below with the following microscopic pictures. More than one picture may fit each description. A picture may be used more than once or not used at all.



- a gaseous compound
- a mixture of two gaseous elements
- a solid element
- a mixture of a gaseous element and a gaseous compound

84. Define the following terms: solid, liquid, gas, pure substance, element, compound, homogeneous mixture, heterogeneous mixture, solution, chemical change, physical change.

85. What is the difference between homogeneous and heterogeneous matter? Classify each of the following as homogeneous or heterogeneous.

- | | |
|----------------------------|------------------------|
| a. a door | d. the water you drink |
| b. the air you breathe | e. salsa |
| c. a cup of coffee (black) | f. your lab partner |

86. Classify the following mixtures as homogeneous or heterogeneous.

- | | |
|---------------------|-----------------|
| a. potting soil | d. window glass |
| b. white wine | e. granite |
| c. your sock drawer | |

87. Classify each of the following as a mixture or a pure substance.

- | | |
|---------------|---------------|
| a. water | f. uranium |
| b. blood | g. wine |
| c. the oceans | h. leather |
| d. iron | i. table salt |
| e. brass | |

Of the pure substances, which are elements and which are compounds?

88. Suppose a teaspoon of magnesium filings and a teaspoon of powdered sulfur are placed together in a metal beaker. Would this constitute a mixture or a pure substance? Suppose the magnesium filings and sulfur are heated so that they react with each other, forming magnesium sulfide. Would this still be a "mixture"? Why or why not?

89. If a piece of hard, white blackboard chalk is heated strongly in a flame, the mass of the piece of chalk will decrease, and eventually the chalk will crumble into a fine white dust. Does this change suggest that the chalk is composed of an element or a compound?

90. During a very cold winter, the temperature may remain below freezing for extended periods. However, fallen snow can still disappear, even though it cannot melt. This is possible because a solid can vaporize directly, without passing through the liquid state. Is this process (sublimation) a physical or a chemical change?

91. Classify the following as physical or chemical changes.

- Moth balls gradually vaporize in a closet.
- Hydrofluoric acid attacks glass and is used to etch calibration marks on glass laboratory utensils.
- A French chef making a sauce with brandy is able to boil off the alcohol from the brandy, leaving just the brandy flavoring.
- Chemistry majors sometimes get holes in the cotton jeans they wear to lab because of acid spills.

92. The properties of a mixture are typically averages of the properties of its components. The properties of a compound may differ dramatically from the properties of the elements that combine to produce the compound. For each process described below, state whether the material being discussed is most likely a mixture or a compound, and state whether the process is a chemical change or a physical change.

- An orange liquid is distilled, resulting in the collection of a yellow liquid and a red solid.
- A colorless, crystalline solid is decomposed, yielding a pale yellow-green gas and a soft, shiny metal.
- A cup of tea becomes sweeter as sugar is added to it.

Additional Exercises

93. Two spherical objects have the same mass. One floats on water; the other sinks. Which object has the greater diameter? Explain.

94. A 194-g sample of caffeine ($C_8H_{10}N_4O_2$) contains 6.02×10^{23} molecules of caffeine. If a typical 10-hour energy drink contains 422 mg of caffeine, how many molecules of caffeine are present in the drink?



95. Lipitor, a pharmaceutical drug that has been shown to lower "bad" cholesterol levels while raising "good" cholesterol levels in patients taking the drug, had over \$3 billion in sales in 2015. Assuming one 2.5-g pill contains 4.0% of the active ingredient by mass, what mass in kg of active ingredient is present in one bottle of 100 pills?

96. In Shakespeare's *Richard III*, the First Murderer says:

"Take that, and that! [*Stabs Clarence*]

If that is not enough, I'll drown you in a malmsey butt within!" Given that 1 butt = 126 gal, in how many liters of malmsey (a foul brew similar to mead) was the unfortunate Clarence about to be drowned?

97. The contents of one 40. lb bag of topsoil will cover 10. square feet of ground to a depth of 1.0 inch. What number of bags is needed to cover a plot that measures 200. by 300. m to a depth of 4.0 cm?

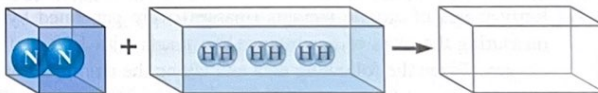
22. Section 2.3 describes the postulates of Dalton's atomic theory. With some modifications, these postulates hold up very well regarding how we view elements, compounds, and chemical reactions today. Answer the following questions concerning Dalton's atomic theory and the modifications made today.
- The atom can be broken down into smaller parts. What are the smaller parts?
 - How are atoms of hydrogen identical to each other, and how can they be different from each other?
 - How are atoms of hydrogen different from atoms of helium? How can H atoms be similar to He atoms?
 - How is water different from hydrogen peroxide (H_2O_2) even though both compounds are composed of only hydrogen and oxygen?
 - What happens in a chemical reaction, and why is mass conserved in a chemical reaction?
23. The contributions of J. J. Thomson and Ernest Rutherford led the way to today's understanding of the structure of the atom. What were their contributions?
24. What is the modern view of the structure of the atom?
25. The number of protons in an atom determines the identity of the atom. What does the number and arrangement of the electrons in an atom determine? What does the number of neutrons in an atom determine?
26. If the volume of a proton were similar to the volume of an electron, how will the densities of these two particles compare to each other?
27. For lighter, stable isotopes, the ratio of the mass number to the atomic number is close to a certain value. What is the value? What happens to the value of the mass number to atomic number ratio as stable isotopes become heavier?
28. List some characteristic properties that distinguish the metallic elements from the nonmetallic elements.
29. Consider the elements of Group 4A (the "carbon family"): C, Si, Ge, Sn, and Pb. What is the trend in metallic character as one goes down this group? What is the trend in metallic character going from left to right across a period in the periodic table?
30. Chlorine has two natural isotopes: ^{37}Cl and ^{35}Cl . Hydrogen reacts with chlorine to form the compound HCl. Would a given amount of hydrogen react with different masses of the two chlorine isotopes? Does this conflict with the law of definite proportion? Why or why not?
31. Before an electrocardiogram (ECG) is recorded for a cardiac patient, the ECG leads are usually coated with a moist paste containing sodium chloride. Why is sodium chloride applied to the leads?
32. Distinguish between the following terms.
- molecule versus ion
 - covalent bonding versus ionic bonding
 - molecule versus compound
 - anion versus cation
33. Label the type of bonding for each of the following.
- 
 - 
34. The vitamin niacin (nicotinic acid, $\text{C}_6\text{H}_5\text{NO}_2$) can be isolated from a variety of natural sources such as liver, yeast, milk, and whole grain. It also can be synthesized from commercially available materials. From a nutritional point of view, which source of nicotinic acid is best for use in a multivitamin tablet? Why?
35. Which of the following statements is(are) *true*? For the false statements, correct them.
- Most of the known elements are metals.
 - Element 118 should be a nonmetal.
 - Hydrogen has mostly metallic properties.
 - A family of elements is also known as a period of elements.
 - When an alkaline earth metal, A, reacts with a halogen, X, the formula of the covalent compound formed should be A_2X .
36. Each of the following compounds has three possible names listed for it. For each compound, what is the correct name and why aren't the other names used?
- N_2O : nitrogen oxide, nitrogen(I) oxide, dinitrogen monoxide
 - Cu_2O : copper oxide, copper(I) oxide, dicopper monoxide
 - Li_2O : lithium oxide, lithium(I) oxide, dilithium monoxide

Exercises

In this section similar exercises are paired.

Development of the Atomic Theory

37. When mixtures of gaseous H_2 and gaseous Cl_2 react, a product forms that has the same properties regardless of the relative amounts of H_2 and Cl_2 used.
- How is this result interpreted in terms of the law of definite proportion?
 - When a volume of H_2 reacts with an equal volume of Cl_2 at the same temperature and pressure, what volume of product having the formula HCl is formed?
38. Observations of the reaction between nitrogen gas and hydrogen gas show us that 1 volume of nitrogen reacts with 3 volumes of hydrogen to make 2 volumes of gaseous product, as shown below:



Determine the formula of the product and justify your answer.

39. A sample of chloroform is found to contain 12.0 g of carbon, 106.4 g of chlorine, and 1.01 g of hydrogen. If a second sample of chloroform is found to contain 30.0 g of carbon, what is the total mass of chloroform in the second sample?
40. A sample of H_2SO_4 contains 2.02 g of hydrogen, 32.07 g of sulfur, and 64.00 g of oxygen. How many grams of sulfur and grams of oxygen are present in a second sample of H_2SO_4 containing 7.27 g of hydrogen?

41. Consider 80.0-g samples of two different compounds consisting of only carbon and oxygen. One of the compounds consists of 21.8 g of carbon, and the other has 34.3 g of carbon. Determine the ratio in whole numbers of the masses of carbon that combine with 1.00 g of oxygen between the two compounds.
42. Several compounds containing sulfur and fluorine are known. Three of them have the following compositions:
- 1.188 g of F for every 1.000 g of S
 - 2.375 g of F for every 1.000 g of S
 - 3.563 g of F for every 1.000 g of S

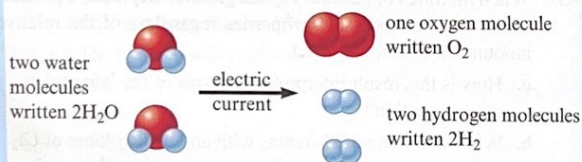
How do these data illustrate the law of multiple proportions?

43. The three most stable oxides of carbon are carbon monoxide (CO), carbon dioxide (CO₂), and carbon suboxide (C₃O₂). The molecules can be represented as



Explain how these molecules illustrate the law of multiple proportions.

44. Two elements, R and Q, combine to form two binary compounds. In the first compound, 14.0 g of R combines with 3.00 g of Q. In the second compound, 7.00 g of R combines with 4.50 g of Q. Show that these data are in accord with the law of multiple proportions. If the formula of the second compound is RQ, what is the formula of the first compound?
45. In Section 1.1 of the text, the concept of a chemical reaction was introduced with the example of the decomposition of water, represented as follows:



Use ideas from Dalton's atomic theory to explain how the above representation illustrates the law of conservation of mass.

46. In a combustion reaction, 46.0 g of ethanol reacts with 96.0 g of oxygen to produce water and carbon dioxide. If 54.0 g of water is produced, what mass of carbon dioxide is produced?
47. Early tables of atomic weights (masses) were generated by measuring the mass of a substance that reacts with 1.00 g of oxygen. Given the following data and taking the atomic mass of hydrogen as 1.00, generate a table of relative atomic masses for oxygen, sodium, and magnesium.

| Element | Mass That Combines with 1.00 g Oxygen | Assumed Formula |
|-----------|---------------------------------------|-----------------|
| Hydrogen | 0.126 g | HO |
| Sodium | 2.875 g | NaO |
| Magnesium | 1.500 g | MgO |

How do your values compare with those in the periodic table? How do you account for any differences?

48. Indium oxide contains 4.784 g of indium for every 1.000 g of oxygen. In 1869, when Mendeleev first presented his version of the periodic table, he proposed the formula In₂O₃ for indium oxide. Before that time it was thought that the formula was InO. What values for the atomic mass of indium are obtained using these two formulas? Assume that oxygen has an atomic mass of 16.00.

The Nature of the Atom

49. From the information in this chapter on the mass of the proton, the mass of the electron, and the sizes of the nucleus and the atom, calculate the densities of a hydrogen nucleus and a hydrogen atom.
50. If you wanted to make an accurate scale model of the hydrogen atom and decided that the nucleus would have a diameter of 1 mm, what would be the diameter of the entire model?
51. In an experiment it was found that the total charge on an oil drop was 5.93×10^{-18} C. How many negative charges does the drop contain?
52. A chemist in a galaxy far, far away performed the Millikan oil drop experiment and got the following results for the charges on various drops. Use these data to calculate the charge of the electron in zirkombs.
- | | |
|---------------------------------|---------------------------------|
| 2.56×10^{-12} zirkombs | 7.68×10^{-12} zirkombs |
| 3.84×10^{-12} zirkombs | 6.40×10^{-13} zirkombs |
53. Give the names of the metals that correspond to the following symbols: Sn, Pt, Hg, Mg, K, Ag.
54. What are the symbols of the following nonmetals: fluorine, chlorine, bromine, sulfur, oxygen, phosphorus?
55. In the periodic table, how many elements are found in each of the following?
- Group 2A
 - the oxygen family
 - the nickel group
 - Group 8A
56. In the periodic table, how many elements are found in each of the following?
- the halogen family
 - the alkali family
 - the lanthanide series
 - transition metals
57. a. Classify the following elements as metals or nonmetals:
- | | | |
|----|----|----|
| Mg | Si | Rn |
| Ti | Ge | Eu |
| Au | B | Am |
| Bi | At | Br |
- b. The distinction between metals and nonmetals is really not a clear one. Some elements, called *metalloids*, are intermediate in their properties. Which of these elements would you reclassify as metalloids? What other elements in the periodic table would you expect to be metalloids?
58. a. List the noble gas elements. Which of the noble gases has only radioactive isotopes? (This situation is indicated on most periodic tables by parentheses around the mass of the element. See inside front cover.)
- b. Which lanthanide element has only radioactive isotopes?

59. For each of the following sets of elements, label each as either noble gases, halogens, alkali metals, alkaline earth metals, or transition metals.

- a. Ti, Fe, Ag
 b. Mg, Sr, Ba
 c. Li, K, Rb
 d. Ne, Kr, Xe
 e. F, Br, I

60. Identify the elements that correspond to the following atomic numbers. Label each as either a noble gas, a halogen, an alkali metal, an alkaline earth metal, a transition metal, a lanthanide metal, or an actinide metal.

- a. 17
 b. 4
 c. 63
 d. 72
 e. 2
 f. 92
 g. 55

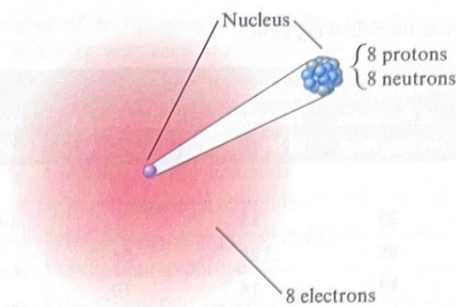
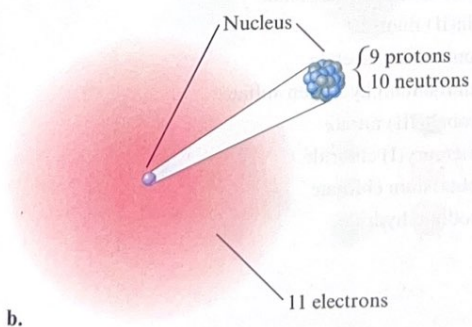
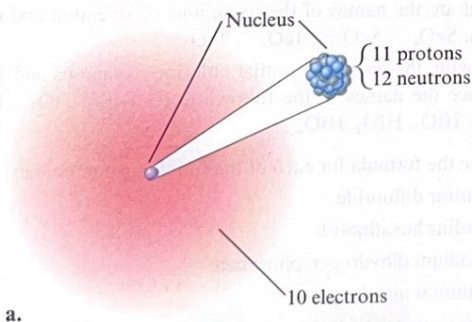
61. Write the atomic symbol (A_ZX) for each of the following isotopes.

- a. $Z = 8$, number of neutrons = 9
 b. the isotope of chlorine in which $A = 37$
 c. $Z = 27$, $A = 60$
 d. number of protons = 26, number of neutrons = 31
 e. the isotope of I with a mass number of 131
 f. $Z = 3$, number of neutrons = 4

62. Write the atomic symbol (A_ZX) for each of the isotopes described below.

- a. number of protons = 27, number of neutrons = 31
 b. the isotope of boron with mass number 10
 c. $Z = 12$, $A = 23$
 d. atomic number 53, number of neutrons = 79
 e. $Z = 20$, number of neutrons = 27
 f. number of protons = 29, mass number 65

63. Write the symbol of each atom using the A_ZX format.



c.

64. For carbon-14 and carbon-12, how many protons and neutrons are in each nucleus? Assuming neutral atoms, how many electrons are present in an atom of carbon-14 and in an atom of carbon-12?

65. How many protons and neutrons are in the nucleus of each of the following atoms? In a neutral atom of each element, how many electrons are present?

- a. ${}^{79}\text{Br}$
 b. ${}^{81}\text{Br}$
 c. ${}^{239}\text{Pu}$
 d. ${}^{133}\text{Cs}$
 e. ${}^3\text{H}$
 f. ${}^{56}\text{Fe}$

66. What number of protons and neutrons are contained in the nucleus of each of the following atoms? Assuming each atom is uncharged, what number of electrons are present?

- a. ${}^{235}_{92}\text{U}$
 b. ${}^{27}_{13}\text{Al}$
 c. ${}^{57}_{26}\text{Fe}$
 d. ${}^{208}_{82}\text{Pb}$
 e. ${}^{86}_{37}\text{Rb}$
 f. ${}^{41}_{20}\text{Ca}$

67. For each of the following ions, indicate the number of protons and electrons the ion contains.

- a. Ba^{2+}
 b. Zn^{2+}
 c. N^{3-}
 d. Rb^{+}
 e. Co^{3+}
 f. Te^{2-}
 g. Br^{-}

68. How many protons, neutrons, and electrons are in each of the following atoms or ions?

- a. ${}^{24}_{12}\text{Mg}$
 b. ${}^{24}_{12}\text{Mg}^{2+}$
 c. ${}^{59}_{27}\text{Co}^{2+}$
 d. ${}^{59}_{27}\text{Co}^{3+}$
 e. ${}^{59}_{27}\text{Co}$
 f. ${}^{79}_{34}\text{Se}$
 g. ${}^{79}_{34}\text{Se}^{2-}$
 h. ${}^{63}_{28}\text{Ni}$
 i. ${}^{58}_{28}\text{Ni}^{2+}$

69. What is the symbol for an ion with 63 protons, 60 electrons, and 88 neutrons? If an ion contains 50 protons, 68 neutrons, and 48 electrons, what is its symbol?

70. What is the symbol of an ion with 16 protons, 18 neutrons, and 18 electrons? What is the symbol for an ion that has 16 protons, 16 neutrons, and 18 electrons?

71. Complete the following table:

| Symbol | Number of Protons in Nucleus | Number of Neutrons in Nucleus | Number of Electrons | Net Charge |
|-------------------------|------------------------------|-------------------------------|---------------------|------------|
| ${}^{238}_{92}\text{U}$ | 20 | 20 | | 2+ |
| | 23 | 28 | 20 | |
| ${}^{89}_{39}\text{Y}$ | 35 | 44 | 36 | |
| | 15 | 16 | | 3- |

72. Complete the following table:

| Symbol | Number of Protons in Nucleus | Number of Neutrons in Nucleus | Number of Electrons | Net Charge |
|------------------------------|------------------------------|-------------------------------|---------------------|------------|
| ${}^{53}_{26}\text{Fe}^{2+}$ | 26 | 33 | | 3+ |
| | 85 | 125 | 86 | |
| | 13 | 14 | 10 | |
| | | 76 | 54 | 2- |

73. Would you expect each of the following atoms to gain or lose electrons when forming ions? What ion is the most likely in each case?

- a. Ra c. P e. Br
b. In d. Te f. Rb

74. For each of the following atomic numbers, use the periodic table to write the formula (including the charge) for the simple ion that the element is most likely to form in ionic compounds.

- a. 13 c. 56 e. 87
b. 34 d. 7 f. 35

Nomenclature

75. Name the compounds in parts a–d and write the formulas for the compounds in parts e–h.

- a. NaBr e. strontium fluoride
b. Rb_2O f. aluminum selenide
c. CaS g. potassium nitride
d. AlI_3 h. magnesium phosphide

76. Name the compounds in parts a–d and write the formulas for the compounds in parts e–h.

- a. Hg_2O e. tin(II) nitride
b. FeBr_3 f. cobalt(III) iodide
c. CoS g. mercury(II) oxide
d. TiCl_4 h. chromium(VI) sulfide

77. Name each of the following compounds:

- a. CsF d. MnO_2
b. Li_3N e. TiO_2
c. Ag_2S f. Sr_3P_2

78. Write the formula for each of the following compounds:

- a. zinc chloride d. aluminum sulfide
b. tin(IV) fluoride e. mercury(I) selenide
c. calcium nitride f. silver iodide

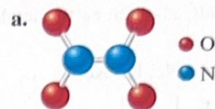
79. Name each of the following compounds:

- a. BaSO_3 c. KMnO_4
b. NaNO_2 d. $\text{K}_2\text{Cr}_2\text{O}_7$

80. Write the formula for each of the following compounds:

- a. chromium(III) hydroxide c. lead(IV) carbonate
b. magnesium cyanide d. ammonium acetate

81. Name each of the following compounds:

c. SO_2 d. P_2S_5

82. Write the formula for each of the following compounds:

- a. diboron trioxide
b. arsenic pentafluoride
c. dinitrogen monoxide
d. sulfur hexachloride

83. Name each of the following compounds:

- a. CuI f. S_4N_4
b. CuI_2 g. SeCl_4
c. CoI_2 h. NaOCl
d. Na_2CO_3 i. BaCrO_4
e. NaHCO_3 j. NH_4NO_3

84. Name each of the following compounds. Assume the acids are dissolved in water.

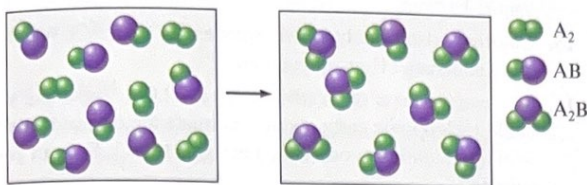
- a. $\text{HC}_2\text{H}_3\text{O}_2$ g. H_2SO_4
b. NH_4NO_2 h. Sr_3N_2
c. CO_2S_3 i. $\text{Al}_2(\text{SO}_3)_3$
d. ICl j. SnO_2
e. $\text{Pb}_3(\text{PO}_4)_2$ k. Na_2CrO_4
f. KClO_3 l. HClO

85. Elements in the same family often form oxyanions of the same general formula. The anions are named in a similar fashion. What are the names of the oxyanions of selenium and tellurium: SeO_4^{2-} , SeO_3^{2-} , TeO_4^{2-} , TeO_3^{2-} ?86. Knowing the names of similar chlorine oxyanions and acids, deduce the names of the following: IO^- , IO_2^- , IO_3^- , IO_4^- , HIO, HIO_2 , HIO_3 , HIO_4 .

87. Write the formula for each of the following compounds:

- a. sulfur difluoride
b. sulfur hexafluoride
c. sodium dihydrogen phosphate
d. lithium nitride
e. chromium(III) carbonate
f. tin(II) fluoride
g. ammonium acetate
h. ammonium hydrogen sulfate
i. cobalt(III) nitrate
j. mercury(I) chloride
k. potassium chlorate
l. sodium hydride

7. Consider the hypothetical reaction between A_2 and AB pictured below.



What is the balanced equation? If 2.50 moles of A_2 are reacted with excess AB, what amount (moles) of product will form? If the mass of AB is 30.0 u and the mass of A_2 are 40.0 u, what is the mass of the product? If 15.0 g of AB is reacted, what mass of A_2 is required to react with all of the AB, and what mass of product is formed?

8. What is a limiting reactant problem? Explain the method you are going to use to solve limiting reactant problems.

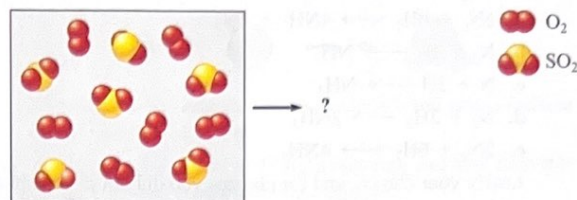
Active Learning Questions

These questions are designed to be used by groups of students in class.

- The following are actual student responses to the question: Why is it necessary to balance chemical equations?
 - The chemicals will not react until you have added the correct mole ratios.
 - The correct products will not be formed unless the right amount of reactants have been added.
 - A certain number of products cannot be formed without a certain number of reactants.
 - The balanced equation tells you how much reactant you need and allows you to predict how much product you'll make.
 - A mole-to-mole ratio must be established for the reaction to occur as written.

Justify the best choice, and for choices you did not pick, explain what is wrong with them.
- What information do we get from a chemical formula? From a chemical equation?
- True or false?* The atom with the largest subscript in a formula is the atom with the largest percent by mass in the compound. If *true*, explain why with an example. If *false*, explain why with an example. In either case, provide mathematical support.
- You have a 20.0-g sample of silver metal. You are given 10.0 g of another metal and told that this sample contains twice the number of atoms as the sample of silver metal. Is this possible?
- You are making cookies and are missing a key ingredient—eggs. You have most of the other ingredients needed to make the cookies, except you have only 1.33 cups of butter and no eggs. You note that the recipe calls for two cups of

9. Consider the following mixture of $SO_2(g)$ and $O_2(g)$.



If $SO_2(g)$ and $O_2(g)$ react to form $SO_3(g)$, draw a representation of the product mixture assuming the reaction goes to completion. What is the limiting reactant in the reaction? If 96.0 g of SO_2 react with 32.0 g O_2 , what mass of product will form?



10. Why is the actual yield of a reaction often less than the theoretical yield?

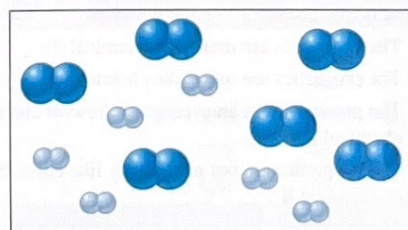
butter and three eggs (plus the other ingredients) to make six dozen cookies. You call a friend and have him bring you some eggs.

- What number of eggs do you need?
- If you use all the butter (and get enough eggs), what number of cookies will you make?

Unfortunately, your friend hangs up before you tell him how many eggs you need. When he arrives, he has a surprise for you—to save time, he has broken them all in a bowl for you. You ask him how many he brought, and he replies, "I can't remember." You weigh the eggs and find that they weigh 62.1 g. Assuming that an average egg weighs 34.21 g,

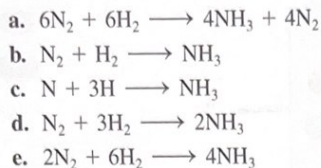
- What quantity of butter is needed to react with all the eggs?
 - What number of cookies can you make?
 - Which will you have left over, eggs or butter?
 - What quantity is left over?
6. Nitrogen gas (N_2) and hydrogen gas (H_2) react to form ammonia gas (NH_3).

Consider the mixture of N_2 () and H_2 () in a closed container as illustrated below:



Assuming the reaction goes to completion, draw a representation of the product mixture. Explain how you arrived at this representation.

7. For the preceding question, which of the following equations best represents the reaction?



Justify your choice, and for choices you did not pick, explain what is wrong with them.

8. You know that chemical *A* reacts with chemical *B*. You react 10.0 g *A* with 10.0 g *B*. What information do you need to determine the amount of product that will be produced? Explain.
9. A new grill has a mass of 30.0 kg. You put 3.0 kg of charcoal in the grill. You burn all the charcoal and the grill has a mass of 30.0 kg. What is the mass of the gases given off? Explain.
10. Consider an iron bar on a balance as shown.



As the iron bar rusts, which of the following is *true*? Explain your answer.

- a. The balance will read less than 75.0 g.
 b. The balance will read 75.0 g.
 c. The balance will read greater than 75.0 g.
 d. The balance will read greater than 75.0 g, but if the bar is removed, the rust is scraped off, and the bar replaced, the balance will read 75.0 g.
11. You may have noticed that water sometimes drips from the exhaust of a car as it is running. Is this evidence that there is at least a small amount of water originally present in the gasoline? Explain.

Questions 12 and 13 deal with the following situation: You react chemical *A* with chemical *B* to make one product. It takes 100 g of *A* to react completely with 20 g of *B*.

12. What is the mass of the product?
- a. less than 10 g
 b. between 20 and 100 g
 c. between 100 and 120 g
 d. exactly 120 g
 e. more than 120 g
13. What is true about the chemical properties of the product?
- a. The properties are more like chemical *A*.
 b. The properties are more like chemical *B*.
 c. The properties are an average of those of chemical *A* and chemical *B*.
 d. The properties are not necessarily like either chemical *A* or chemical *B*.
 e. The properties are more like chemical *A* or more like chemical *B*, but more information is needed.

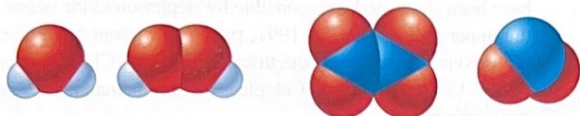
Justify your choice, and for choices you did not pick, explain what is wrong with them.

14. Is there a difference between a homogeneous mixture of hydrogen and oxygen in a 2:1 mole ratio and a sample of water vapor? Explain.
15. Chlorine exists mainly as two isotopes, ^{37}Cl and ^{35}Cl . Which is more abundant? How do you know?
16. The average mass of a carbon atom is 12.011. Assuming you could pick up one carbon atom, estimate the chance that you would randomly get one with a mass of 12.011. Support your answer.
17. Can the subscripts in a chemical formula be fractions? Explain. Can the coefficients in a balanced chemical equation be fractions? Explain. Changing the subscripts of chemicals can balance the equations mathematically. Why is this unacceptable?
18. Consider the equation $2\text{A} + \text{B} \longrightarrow \text{A}_2\text{B}$. If you mix 1.0 mole of *A* with 1.0 mole of *B*, what amount (moles) of A_2B can be produced?
19. According to the law of conservation of mass, mass cannot be gained or destroyed in a chemical reaction. Why can't you simply add the masses of two reactants to determine the total mass of product?
20. Which of the following pairs of compounds have the same empirical formula?
- a. acetylene, C_2H_2 , and benzene, C_6H_6
 b. ethane, C_2H_6 , and butane, C_4H_{10}
 c. nitrogen dioxide, NO_2 , and dinitrogen tetroxide, N_2O_4
 d. diphenyl ether, $\text{C}_{12}\text{H}_{10}\text{O}$, and phenol, $\text{C}_6\text{H}_5\text{OH}$
21. Atoms of three different elements are represented by O, □, and Δ. Which compound is left over when three molecules of OΔ and three molecules of □□Δ react to form O□Δ and OΔΔ?
22. In chemistry, what is meant by the term "mole"? What is the importance of the mole concept?
23. Which (if any) of the following is(are) *true* regarding the limiting reactant in a chemical reaction?
- a. The limiting reactant has the lowest coefficient in a balanced equation.
 b. The limiting reactant is the reactant for which you have the fewest number of moles.
 c. The limiting reactant has the lowest ratio of moles available/coefficient in the balanced equation.
 d. The limiting reactant has the lowest ratio of coefficient in the balanced equation/moles available.
- Justify your choice. For those you did not choose, explain why they are incorrect.
24. Consider the equation $3\text{A} + \text{B} \rightarrow \text{C} + \text{D}$. You react 4 moles of *A* with 2 moles of *B*. Which of the following is *true*?
- a. The limiting reactant is the one with the higher molar mass.
 b. *A* is the limiting reactant because you need 6 moles of *A* and have 4 moles.
 c. *B* is the limiting reactant because you have fewer moles of *B* than *A*.
 d. *B* is the limiting reactant because three *A* molecules react with each *B* molecule.
 e. Neither reactant is limiting.
- Justify your choice. For those you did not choose, explain why they are incorrect.

A blue question or exercise number indicates that the answer to that question or exercise appears at the back of the book and a solution appears in the *Solutions Guide*, as found on the Instructor Companion Site.

Questions

- The atomic masses in the periodic table are relative masses and average masses. Explain.
- Avogadro's number, molar mass, and the chemical formula of a compound are three useful conversion factors. What unit conversions can be accomplished using these conversion factors?
- If you had a mole of U.S. dollar bills and equally distributed the money to all of the people of the world, how rich would every person be? Assume a world population of 7 billion.
- Describe 1 mole of CO_2 in as many ways as you can.
- Which of the following compounds have the same empirical formulas?



a.

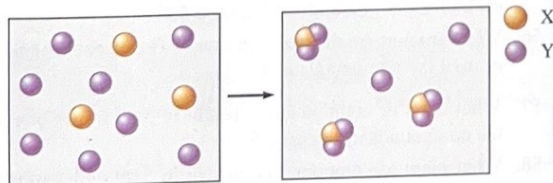
b.



c.

d.

- What is the difference between the molar mass and the empirical formula mass of a compound? When are these masses the same, and when are they different? When different, how is the molar mass related to the empirical formula mass?
- How is the mass percent of elements in a compound different for a 1.0-g sample versus a 100.-g sample versus a 1-mole sample of the compound?
- A balanced chemical equation contains a large amount of information. What information is given in a balanced equation?
- The reaction of an element X with element Y is represented in the following diagram. Which of the equations best describes this reaction?



- $3X + 8Y \rightarrow X_3Y_8$
- $3X + 6Y \rightarrow X_3Y_6$
- $X + 2Y \rightarrow XY_2$
- $3X + 8Y \rightarrow 3XY_2 + 2Y$

- Hydrogen gas and oxygen gas react to form water, and this reaction can be depicted as follows:



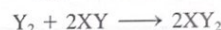
Explain why this equation is not balanced, and draw a picture of the balanced equation.

- What is the theoretical yield for a reaction, and how does this quantity depend on the limiting reactant?
- What does it mean to say a reactant is present "in excess" in a process? Can the limiting reactant be present in excess? Does the presence of an excess of a reactant affect the mass of products expected for a reaction?
- Consider the following generic reaction:



What steps and information are necessary to perform the following determinations assuming that 1.00×10^4 molecules of A_2B_2 are reacted with excess C?

- mass of CB produced
 - atoms of A produced
 - moles of C reacted
 - percent yield of CB
- Consider the following generic reaction:



In a limiting reactant problem, a certain quantity of each reactant is given and you are usually asked to calculate the mass of product formed. If 10.0 g of Y_2 is reacted with 10.0 g of XY, outline two methods you could use to determine which reactant is limiting (runs out first) and thus determines the mass of product formed.

Exercises

In this section similar exercises are paired.

Atomic Masses and the Mass Spectrometer

- An element consists of 1.40% of an isotope with mass 203.973 u, 24.10% of an isotope with mass 205.9745 u, 22.10% of an isotope with mass 206.9759 u, and 52.40% of an isotope with mass 207.9766 u. Calculate the average atomic mass, and identify the element.
- An element "X" has five major isotopes, which are listed below along with their abundances. What is the element?

| Isotope | Percent Natural Abundance | Mass (u) |
|-----------------|---------------------------|-----------|
| ^{46}X | 8.00% | 45.95232 |
| ^{47}X | 7.30% | 46.951764 |
| ^{48}X | 73.80% | 47.947947 |
| ^{49}X | 5.50% | 48.947841 |
| ^{50}X | 5.40% | 49.944792 |

41. The element rhenium (Re) has two naturally occurring isotopes, ^{185}Re and ^{187}Re , with an average atomic mass of 186.207 u. Rhenium is 62.60% ^{187}Re , and the atomic mass of ^{187}Re is 186.956 u. Calculate the mass of ^{185}Re .
42. Assume silicon has three major isotopes in nature as shown in the table below. Fill in the missing information.

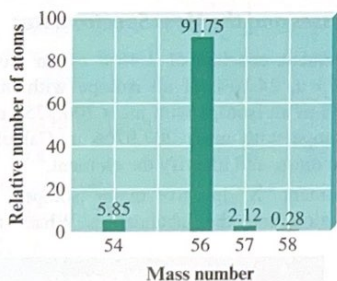
| Isotope | Mass (u) | Abundance |
|------------------|----------|-----------|
| ^{28}Si | 27.98 | _____ |
| ^{29}Si | _____ | 4.70% |
| ^{30}Si | 29.97 | 3.09% |

43. The element europium exists in nature as two isotopes: ^{151}Eu has a mass of 150.9196 u and ^{153}Eu has a mass of 152.9209 u. The average atomic mass of europium is 151.96 u. Calculate the relative abundance of the two europium isotopes.
44. The element silver (Ag) has two naturally occurring isotopes: ^{109}Ag and ^{107}Ag with a mass of 106.905 u. Silver consists of 51.82% ^{107}Ag and has an average atomic mass of 107.868 u. Calculate the mass of ^{109}Ag .
45. The mass spectrum of bromine (Br_2) consists of three peaks with the following characteristics:

| Mass (u) | Relative Size |
|----------|---------------|
| 157.84 | 0.2534 |
| 159.84 | 0.5000 |
| 161.84 | 0.2466 |

How do you interpret these data?

46. The stable isotopes of iron are ^{54}Fe , ^{56}Fe , ^{57}Fe , and ^{58}Fe . The mass spectrum of iron looks like the following:

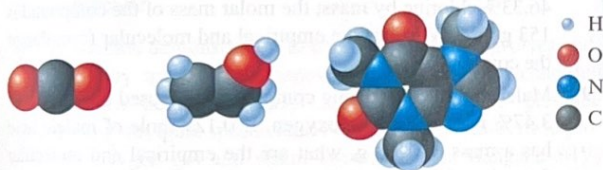


Use the data on the mass spectrum to estimate the average atomic mass of iron, and compare it to the value given in the table inside the front cover of this book.

Moles and Molar Masses

47. Calculate the mass of 500. atoms of iron (Fe).
48. What number of Fe atoms and what amount (moles) of Fe atoms are in 500.0 g of iron?
49. Diamond is a natural form of pure carbon. What number of atoms of carbon are in a 1.00-carat diamond (1.00 carat = 0.200 g)?
50. Chromium (Cr) is a metal that is added to steel to improve its resistance to corrosion. Calculate the number of moles in a sample of chromium containing 5.00×10^{20} atoms and the mass of the sample.
51. Selective serotonin reuptake inhibitors (SSRIs) are a common prescribed antidepressant. SSRIs block the reabsorption of the neurotransmitter serotonin in the brain. Changing the balance of serotonin helps brain cells send and receive chemical messages, which in turn boosts mood. Two SSRI medications are Prozac (fluoxetine, $\text{C}_{17}\text{H}_{18}\text{F}_3\text{NO}$) and Zoloft (sertraline, $\text{C}_{17}\text{H}_{17}\text{Cl}_2\text{N}$). Determine the molar masses of Prozac and Zoloft.
52. The Freons are a class of compounds containing carbon, chlorine, and fluorine. While they have many valuable uses, they have been shown to be responsible for depletion of the ozone in the upper atmosphere. In 1991, two replacement compounds for Freons went into production: HFC-134a (CH_2FCF_3) and HCFC-124 (CHClFCF_3). Calculate the molar masses of these two compounds.
53. Calculate the molar mass of the following substances.
- -
 - $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
54. Calculate the molar mass of the following substances.
- - $\text{Ca}_3(\text{PO}_4)_2$
 - Na_2HPO_4
55. What amount (moles) of compound is present in 1.00 g of each of the compounds in Exercise 53?
56. What amount (moles) of compound is present in 1.00 g of each of the compounds in Exercise 54?
57. What mass of compound is present in 5.00 moles of each of the compounds in Exercise 53?
58. What mass of compound is present in 5.00 moles of each of the compounds in Exercise 54?
59. What mass of nitrogen is present in 5.00 moles of each of the compounds in Exercise 53?
60. What mass of phosphorus is present in 5.00 moles of each of the compounds in Exercise 54?
61. What number of molecules (or formula units) are present in 1.00 g of each of the compounds in Exercise 53?
62. What number of molecules (or formula units) are present in 1.00 g of each of the compounds in Exercise 54?

63. What number of atoms of nitrogen are present in 1.00 g of each of the compounds in Exercise 53?
64. What number of atoms of phosphorus are present in 1.00 g of each of the compounds in Exercise 54?
65. Freon-12 (CCl_2F_2) is used as a refrigerant in air conditioners and as a propellant in aerosol cans. Calculate the number of molecules of Freon-12 in 5.56 mg of Freon-12. What is the mass of chlorine in 5.56 mg of Freon-12?
66. Prevacid is used to treat gastroesophageal reflux disease (GERD). The chemical formula of Prevacid is $\text{C}_{16}\text{H}_{14}\text{F}_3\text{N}_3\text{O}_2\text{S}$.
- What is the molar mass of Prevacid?
 - What mass of fluorine is in 0.75 mol of Prevacid?
 - What number of carbon atoms is in 0.75 mol of Prevacid?
 - What is the mass of 4.25×10^{21} molecules of Prevacid?
67. What amount (moles) is represented by each of these samples?
- 150.0 g Fe_2O_3
 - 10.0 mg NO_2
 - 1.5×10^{16} molecules of BF_3
68. Consider the following space-filling models for dry ice, ethanol, and caffeine:



Dry ice

Ethanol

Caffeine

What amount (moles) is represented by each of the following samples?

- 1.50 g of dry ice
 - 2.72×10^{21} molecules of ethanol
 - 20.0 mg of caffeine
69. What number of atoms of nitrogen are present in 5.00 g of each of the following?
- glycine, $\text{C}_2\text{H}_5\text{O}_2\text{N}$
 - magnesium nitride
 - calcium nitrate
 - dinitrogen tetroxide
70. Complete the following table.

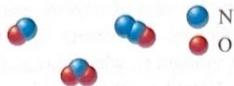
| Mass of Sample | Moles of Sample | Molecules in Sample | Total Atoms in Sample |
|-------------------------------|--------------------------------|---|--|
| 4.24 g C_6H_6 | _____ | _____ | _____ |
| _____ | 0.224 mol H_2O | _____ | _____ |
| _____ | _____ | 2.71×10^{22} molecules CO_2 | _____ |
| _____ | _____ | _____ | 3.35×10^{22} total atoms in CH_3OH sample |

71. Ascorbic acid, or vitamin C ($\text{C}_6\text{H}_8\text{O}_6$), is an essential vitamin. It cannot be stored by the body and must be present in the diet. What is the molar mass of ascorbic acid? Vitamin C tablets are taken as a dietary supplement. If a typical tablet contains 500.0 mg of vitamin C, what amount (moles) of vitamin C is contained in 10 tablets? What number of vitamin C molecules is in eight tablets?
72. The molecular formula of acetylsalicylic acid (aspirin), one of the most commonly used pain relievers, is $\text{C}_9\text{H}_8\text{O}_4$.
- Calculate the molar mass of aspirin.
 - A typical aspirin tablet contains 500. mg $\text{C}_9\text{H}_8\text{O}_4$. What amount (moles) of $\text{C}_9\text{H}_8\text{O}_4$ molecules and what number of molecules of acetylsalicylic acid are in a 500.-mg tablet?
73. Chloral hydrate ($\text{C}_2\text{H}_3\text{Cl}_3\text{O}_2$) is a drug formerly used as a sedative and hypnotic. It is the compound used to make "Mickey Finns" in detective stories.
- Calculate the molar mass of chloral hydrate.
 - What amount (moles) of $\text{C}_2\text{H}_3\text{Cl}_3\text{O}_2$ molecules are in 500.0 g chloral hydrate?
 - What is the mass in grams of 2.0×10^{-2} mole of chloral hydrate?
 - What number of chlorine atoms are in 5.0 g chloral hydrate?
 - What mass of chloral hydrate would contain 1.0 g Cl?
 - What is the mass of exactly 500 molecules of chloral hydrate?
74. Dimethylnitrosamine, $(\text{CH}_3)_2\text{N}_2\text{O}$, is a carcinogenic (cancer-causing) substance that may be formed in foods, beverages, or gastric juices from the reaction of nitrite ion (used as a food preservative) with other substances.
- What is the molar mass of dimethylnitrosamine?
 - How many moles of $(\text{CH}_3)_2\text{N}_2\text{O}$ molecules are present in 250 mg dimethylnitrosamine?
 - What is the mass of 0.050 mole of dimethylnitrosamine?
 - How many atoms of hydrogen are in 1.0 mole of dimethylnitrosamine?
 - What is the mass of 1.0×10^6 molecules of dimethylnitrosamine?
 - What is the mass in grams of one molecule of dimethylnitrosamine?

Percent Composition

75. Calculate the percent composition by mass of the following compounds that are important starting materials for synthetic polymers:
- $\text{C}_3\text{H}_4\text{O}_2$ (acrylic acid, from which acrylic plastics are made)
 - $\text{C}_4\text{H}_6\text{O}_2$ (methyl acrylate, from which Plexiglas is made)
 - $\text{C}_3\text{H}_3\text{N}$ (acrylonitrile, from which Orlon is made)
76. In 1987 the first substance to act as a superconductor at a temperature above that of liquid nitrogen (77 K) was discovered. The approximate formula of this substance is $\text{YBa}_2\text{Cu}_3\text{O}_7$. Calculate the percent composition by mass of this material.

77. The percent by mass of nitrogen for a compound is found to be 46.7%. Which of the following could be this species?



78. Arrange the following substances in order of increasing mass percent of carbon.

- caffeine, $C_8H_{10}N_4O_2$
- sucrose, $C_{12}H_{22}O_{11}$
- ethanol, C_2H_5OH

79. Fungal laccase, a blue protein found in wood-rotting fungi, is 0.390% Cu by mass. If a fungal laccase molecule contains four copper atoms, what is the molar mass of fungal laccase?

80. Hemoglobin is the protein that transports oxygen in mammals. Hemoglobin is 0.347% Fe by mass, and each hemoglobin molecule contains four iron atoms. Calculate the molar mass of hemoglobin.

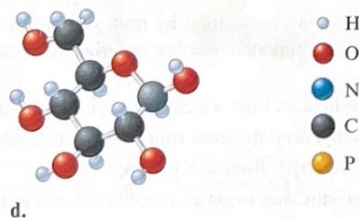
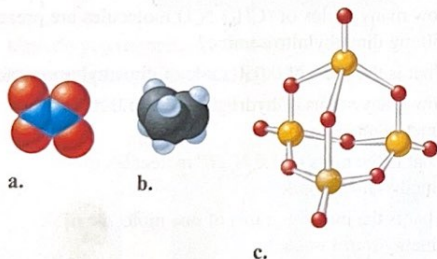
Empirical and Molecular Formulas

81. Express the composition of each of the following compounds as the mass percents of its elements.

- formaldehyde, CH_2O
- glucose, $C_6H_{12}O_6$
- acetic acid, $HC_2H_3O_2$

82. Considering your answer to Exercise 81, which type of formula, empirical or molecular, can be obtained from elemental analysis that gives percent composition?

83. Give the empirical formula for each of the compounds represented below.



84. Determine the molecular formulas to which the following empirical formulas and molar masses pertain.

- SNH (188.35 g/mol)
- $NPCl_2$ (347.64 g/mol)
- CoC_4O_4 (341.94 g/mol)
- SN (184.32 g/mol)

85. A compound that contains only carbon, hydrogen, and oxygen is 48.64% C and 8.16% H by mass. What is the empirical formula of this substance?

86. The most common form of nylon (nylon-6) is 63.68% carbon, 12.38% nitrogen, 9.80% hydrogen, and 14.14% oxygen. Calculate the empirical formula for nylon-6.

87. There are two binary compounds of mercury and oxygen. Heating either of them results in the decomposition of the compound, with oxygen gas escaping into the atmosphere while leaving a residue of pure mercury. Heating 0.6498 g of one of the compounds leaves a residue of 0.6018 g. Heating 0.4172 g of the other compound results in a mass loss of 0.016 g. Determine the empirical formula of each compound.

88. A sample of urea contains 1.121 g N, 0.161 g H, 0.480 g C, and 0.640 g O. What is the empirical formula of urea?

89. A compound containing only sulfur and nitrogen is 69.6% S by mass; the molar mass is 184 g/mol. What are the empirical and molecular formulas of the compound?

90. Determine the molecular formula of a compound that contains 26.7% P, 12.1% N, and 61.2% Cl, and has a molar mass of 580 g/mol.

91. A compound contains 47.08% carbon, 6.59% hydrogen, and 46.33% chlorine by mass; the molar mass of the compound is 153 g/mol. What are the empirical and molecular formulas of the compound?

92. Maleic acid is an organic compound composed of 41.39% C, 3.47% H, and the rest oxygen. If 0.129 mole of maleic acid has a mass of 15.0 g, what are the empirical and molecular formulas of maleic acid?

93. One of the components that make up common table sugar is fructose, a compound that contains only carbon, hydrogen, and oxygen. Complete combustion of 1.50 g of fructose produced 2.20 g of carbon dioxide and 0.900 g of water. What is the empirical formula of fructose?

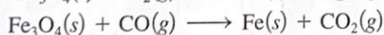
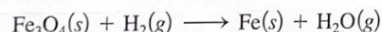
94. A compound contains only C, H, and N. Combustion of 35.0 mg of the compound produces 33.5 mg CO_2 and 41.1 mg H_2O . What is the empirical formula of the compound?

95. Cumene is a compound containing only carbon and hydrogen that is used in the production of acetone and phenol in the chemical industry. Combustion of 47.6 mg cumene produces some CO_2 and 42.8 mg water. The molar mass of cumene is between 115 and 125 g/mol. Determine the empirical and molecular formulas.

96. A compound contains only carbon, hydrogen, and oxygen. Combustion of 10.68 mg of the compound yields 16.01 mg CO_2 and 4.37 mg H_2O . The molar mass of the compound is 176.1 g/mol. What are the empirical and molecular formulas of the compound?

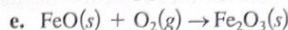
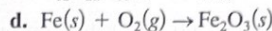
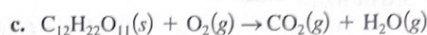
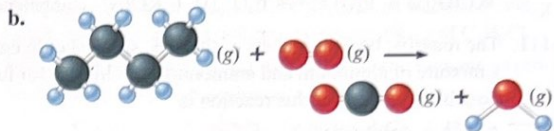
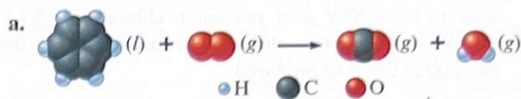
Balancing Chemical Equations

97. Give the balanced equation for each of the following chemical reactions:
- Glucose ($C_6H_{12}O_6$) reacts with oxygen gas to produce gaseous carbon dioxide and water vapor.
 - Solid iron(III) sulfide reacts with gaseous hydrogen chloride to form solid iron(III) chloride and hydrogen sulfide gas.
 - Carbon disulfide liquid reacts with ammonia gas to produce hydrogen sulfide gas and solid ammonium thiocyanate (NH_4SCN).
98. Give the balanced equation for each of the following.
- The combustion of ethanol (C_2H_5OH) forms carbon dioxide and water vapor. A combustion reaction refers to a reaction of a substance with oxygen gas.
 - Aqueous solutions of lead(II) nitrate and sodium phosphate are mixed, resulting in the precipitate formation of lead(II) phosphate with aqueous sodium nitrate as the other product.
 - Solid zinc reacts with aqueous HCl to form aqueous zinc chloride and hydrogen gas.
 - Aqueous strontium hydroxide reacts with aqueous hydrobromic acid to produce water and aqueous strontium bromide.
99. A common demonstration in chemistry courses involves adding a tiny speck of manganese(IV) oxide to a concentrated hydrogen peroxide (H_2O_2) solution. Hydrogen peroxide decomposes quite spectacularly under these conditions to produce oxygen gas and steam (water vapor). Manganese(IV) oxide is a catalyst for the decomposition of hydrogen peroxide and is not consumed in the reaction. Write the balanced equation for the decomposition reaction of hydrogen peroxide.
100. Iron oxide ores, commonly a mixture of FeO and Fe_2O_3 , are given the general formula Fe_3O_4 . They yield elemental iron when heated to a very high temperature with either carbon monoxide or elemental hydrogen. Balance the following equations for these processes:

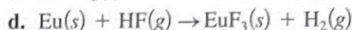
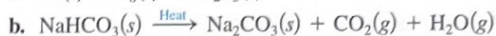
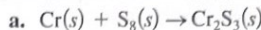


101. Balance the following equations:
- $Ca(OH)_2(aq) + H_3PO_4(aq) \rightarrow H_2O(l) + Ca_3(PO_4)_2(s)$
 - $Al(OH)_3(s) + HCl(aq) \rightarrow AlCl_3(aq) + H_2O(l)$
 - $AgNO_3(aq) + H_2SO_4(aq) \rightarrow Ag_2SO_4(s) + HNO_3(aq)$
102. Balance each of the following chemical equations.
- $KO_2(s) + H_2O(l) \rightarrow KOH(aq) + O_2(g) + H_2O_2(aq)$
 - $Fe_2O_3(s) + HNO_3(aq) \rightarrow Fe(NO_3)_3(aq) + H_2O(l)$
 - $NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g)$
 - $PCl_5(l) + H_2O(l) \rightarrow H_3PO_4(aq) + HCl(g)$
 - $CaO(s) + C(s) \rightarrow CaC_2(s) + CO_2(g)$
 - $MoS_2(s) + O_2(g) \rightarrow MoO_3(s) + SO_2(g)$
 - $FeCO_3(s) + H_2CO_3(aq) \rightarrow Fe(HCO_3)_2(aq)$

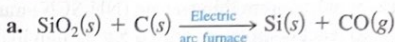
103. Balance the following equations representing combustion reactions:



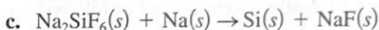
104. Balance the following equations:



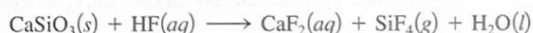
105. Silicon is produced for the chemical and electronics industries by the following reactions. Give the balanced equation for each reaction.



- b. Liquid silicon tetrachloride is reacted with very pure solid magnesium, producing solid silicon and solid magnesium chloride.

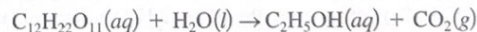


106. Glass is a mixture of several compounds, but a major constituent of most glass is calcium silicate, $CaSiO_3$. Glass can be etched by treatment with hydrofluoric acid; HF attacks the calcium silicate of the glass, producing gaseous and water-soluble products (which can be removed by washing the glass). For example, the volumetric glassware in chemistry laboratories is often graduated by using this process. Balance the following equation for the reaction of hydrofluoric acid with calcium silicate.



107. Phosphorus occurs naturally in the form of fluorapatite, $CaF_2 \cdot 3Ca_3(PO_4)_2$. The dot indicates 1 part CaF_2 to 3 parts $Ca_3(PO_4)_2$. This mineral is reacted with an aqueous solution of H_2SO_4 in the preparation of a fertilizer. The products are phosphoric acid, hydrogen fluoride, and gypsum, $CaSO_4 \cdot 2H_2O$. Write the balanced equation describing this process.

108. The sugar sucrose, which is present in many fruits and vegetables, reacts in the presence of certain yeast enzymes to produce ethanol and carbon dioxide gas. Balance the following equation for this reaction of sucrose.



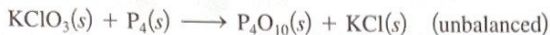
Reaction Stoichiometry

109. Over the years, the thermite reaction has been used for welding railroad rails, in incendiary bombs, and to ignite solid-fuel rocket motors. The reaction is

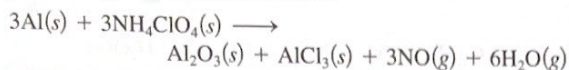


What masses of iron(III) oxide and aluminum must be used to produce 15.0 g iron? What is the maximum mass of aluminum oxide that could be produced?

110. The reaction between potassium chlorate and red phosphorus takes place when you strike a match on a matchbox. If you were to react 52.9 g of potassium chlorate (KClO_3) with excess red phosphorus, what mass of tetraphosphorus decaoxide (P_4O_{10}) could be produced?

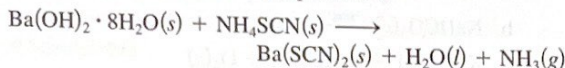


111. The reusable booster rockets of the U.S. space shuttle employ a mixture of aluminum and ammonium perchlorate for fuel. A possible equation for this reaction is



What mass of NH_4ClO_4 should be used in the fuel mixture for every kilogram of Al?

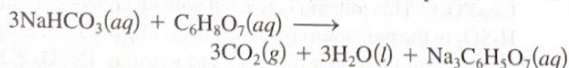
112. One of relatively few reactions that takes place directly between two solids at room temperature is



In this equation, the $\cdot 8\text{H}_2\text{O}$ in $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ indicates the presence of eight water molecules. This compound is called barium hydroxide octahydrate.

- Balance the equation.
 - What mass of ammonium thiocyanate (NH_4SCN) must be used if it is to react completely with 6.5 g barium hydroxide octahydrate?
113. The compound cisplatin, $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$, has been studied as an antitumor agent. Cisplatin is synthesized as follows:
- $$\text{K}_2\text{PtCl}_4(aq) + 2\text{NH}_3(aq) \longrightarrow \text{Pt}(\text{NH}_3)_2\text{Cl}_2(s) + 2\text{KCl}(aq)$$
- What mass of cisplatin can be produced from 100. g of K_2PtCl_4 and sufficient NH_3 ?
114. a. Write the balanced equation for the combustion of isooctane (C_8H_{18}) to produce water vapor and carbon dioxide gas.
 b. Assuming gasoline is 100% isooctane, with a density of 0.692 g/mL, what is the theoretical yield of carbon dioxide produced by the combustion of 1.2×10^{10} gal of gasoline (the approximate annual consumption of gasoline in the United States)?

115. Elixirs such as Alka-Seltzer use the reaction of sodium bicarbonate with citric acid in aqueous solution to produce a fizz:

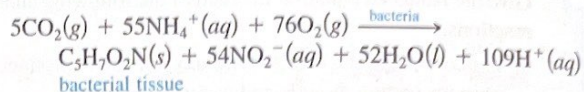


- What mass of $\text{C}_6\text{H}_8\text{O}_7$ should be used for every 1.0×10^2 mg NaHCO_3 ?
 - What mass of $\text{CO}_2(g)$ could be produced from such a mixture?
116. Aspirin ($\text{C}_9\text{H}_8\text{O}_4$) is synthesized by reacting salicylic acid ($\text{C}_7\text{H}_6\text{O}_3$) with acetic anhydride ($\text{C}_4\text{H}_6\text{O}_3$). The balanced equation is



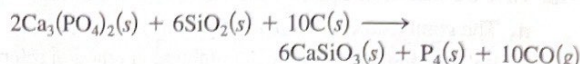
- What mass of acetic anhydride is needed to completely consume 1.00×10^2 g salicylic acid?
- What is the maximum mass of aspirin (the theoretical yield) that could be produced in this reaction?

117. Bacterial digestion is an economical method of sewage treatment. The reaction



is an intermediate step in the conversion of the nitrogen in organic compounds into nitrate ions. What mass of bacterial tissue is produced in a treatment plant for every 1.0×10^4 kg of wastewater containing 3.0% NH_4^+ ions by mass? Assume that 95% of the ammonium ions are consumed by the bacteria.

118. Phosphorus can be prepared from calcium phosphate by the following reaction:



Phosphorite is a mineral that contains $\text{Ca}_3(\text{PO}_4)_2$ plus other non-phosphorus-containing compounds. What is the maximum amount of P_4 that can be produced from 1.0 kg of phosphorite if the phosphorite sample is 75% $\text{Ca}_3(\text{PO}_4)_2$ by mass? Assume an excess of the other reactants.

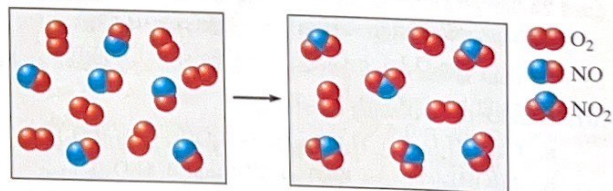
119. Coke is an impure form of carbon that is often used in the industrial production of metals from their oxides. If a sample of coke is 95% carbon by mass, determine the mass of coke needed to react completely with 1.0 ton of copper(II) oxide.



120. The space shuttle environmental control system handled excess CO_2 (which the astronauts breathe out; it is 4.0% by mass of exhaled air) by reacting it with lithium hydroxide, LiOH , pellets to form lithium carbonate, Li_2CO_3 , and water. If there were seven astronauts on board the shuttle, and each exhales 20. L of air per minute, how long could clean air be generated if there were 25,000 g of LiOH pellets available for each shuttle mission? Assume the density of air is 0.0010 g/mL.

Limiting Reactants and Percent Yield

121. Consider the reaction between $\text{NO}(g)$ and $\text{O}_2(g)$ represented below.



What is the balanced equation for this reaction, and what is the limiting reactant?

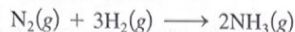
122. Consider the following reaction:



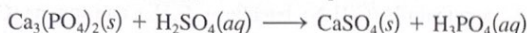
If a container were to have 10 molecules of O_2 and 10 molecules of NH_3 initially, how many total molecules (reactants plus products) would be present in the container after this reaction goes to completion?



123. Ammonia is produced from the reaction of nitrogen and hydrogen according to the following balanced equation:

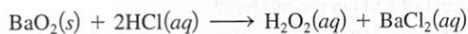


- a. What is the maximum mass of ammonia that can be produced from a mixture of 1.00×10^3 g N_2 and 5.00×10^2 g H_2 ?
- b. What mass of which starting material would remain unreacted?
124. Consider the following unbalanced equation:



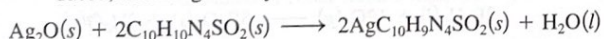
What masses of calcium sulfate and phosphoric acid can be produced from the reaction of 1.0 kg calcium phosphate with 1.0 kg concentrated sulfuric acid (98% H_2SO_4 by mass)?

125. Hydrogen peroxide is used as a cleansing agent in the treatment of cuts and abrasions for several reasons. It is an oxidizing agent that can directly kill many microorganisms; it decomposes on contact with blood, releasing elemental oxygen gas (which inhibits the growth of anaerobic microorganisms); and it foams on contact with blood, which provides a cleansing action. In the laboratory, small quantities of hydrogen peroxide can be prepared by the action of an acid on an alkaline earth metal peroxide, such as barium peroxide:

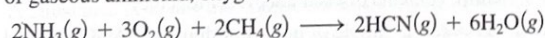


What mass of hydrogen peroxide should result when 1.50 g barium peroxide is treated with 88.0 mL hydrochloric acid solution containing 0.0272 g HCl per mL? What mass of which reagent is left unreacted?

126. Silver sulfadiazine burn-treating cream creates a barrier against bacterial invasion and releases antimicrobial agents directly into the wound. If 25.0 g Ag_2O is reacted with 50.0 g $\text{C}_{10}\text{H}_{10}\text{N}_4\text{SO}_2$, what mass of silver sulfadiazine, $\text{AgC}_{10}\text{H}_9\text{N}_4\text{SO}_2$, can be produced, assuming 100% yield?

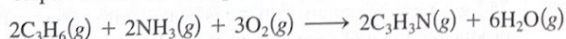


127. Hydrogen cyanide is produced industrially from the reaction of gaseous ammonia, oxygen, and methane:



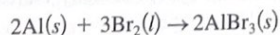
If 5.00×10^3 kg each of NH_3 , O_2 , and CH_4 are reacted, what mass of HCN and of H_2O will be produced, assuming 100% yield?

128. Acrylonitrile ($\text{C}_3\text{H}_3\text{N}$) is the starting material for many synthetic carpets and fabrics. It is produced by the following reaction.



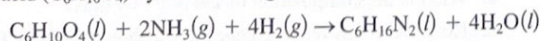
If 15.0 g C_3H_6 , 10.0 g O_2 , and 5.00 g NH_3 are reacted, what mass of acrylonitrile can be produced, assuming 100% yield?

129. Aluminum reacts with bromine, producing aluminum bromide:



In a certain experiment, 20.0 mL of bromine (density = 3.10 g/mL) was reacted with excess aluminum to yield 50.3 g of aluminum bromide. What is the percent yield for this experiment?

130. Hexamethylenediamine ($\text{C}_6\text{H}_{16}\text{N}_2$) is one of the starting materials for the production of nylon. It can be prepared from adipic acid ($\text{C}_6\text{H}_{10}\text{O}_4$) by the following overall equation:



What is the percent yield for the reaction if 765 g of hexamethylenediamine is made from 1.00×10^3 g of adipic acid?

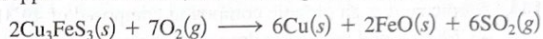
131. The reaction of ethane gas (C_2H_6) with chlorine gas produces $\text{C}_2\text{H}_5\text{Cl}$ as its main product (along with HCl). In addition, the reaction invariably produces a variety of other minor products, including $\text{C}_2\text{H}_4\text{Cl}_2$, $\text{C}_2\text{H}_3\text{Cl}_3$, and others. Naturally, the production of these minor products reduces the yield of the main product. Calculate the percent yield of $\text{C}_2\text{H}_5\text{Cl}$ if the reaction of 300. g of ethane with 650. g of chlorine produced 490. g of $\text{C}_2\text{H}_5\text{Cl}$.

132. DDT, an insecticide harmful to fish, birds, and humans, is produced by the following reaction:



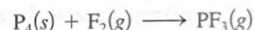
In a government lab, 1142 g of chlorobenzene is reacted with 485 g of chloral.

- a. What mass of DDT is formed, assuming 100% yield?
- b. Which reactant is limiting? Which is in excess?
- c. What mass of the excess reactant is left over?
- d. If the actual yield of DDT is 200.0 g, what is the percent yield?
133. Bornite (Cu_3FeS_3) is a copper ore used in the production of copper. When heated, the following reaction occurs:



If 2.50 metric tons of bornite is reacted with excess O_2 and the process has an 86.3% yield of copper, what mass of copper is produced?

134. Consider the following unbalanced reaction:



What mass of F_2 is needed to produce 120. g of PF_3 if the reaction has a 78.1% yield?

Additional Exercises

135. In using a mass spectrometer, a chemist sees a peak at a mass of 30.0106. Of the choices $^{12}\text{C}_2^1\text{H}_6$, $^{12}\text{C}^1\text{H}_2^{16}\text{O}$, and $^{14}\text{N}^{16}\text{O}$, which is responsible for this peak? Pertinent masses are ^1H , 1.007825; ^{16}O , 15.994915; and ^{14}N , 14.003074.

136. Boron consists of two isotopes, ^{10}B and ^{11}B . Chlorine also has two isotopes, ^{35}Cl and ^{37}Cl . Consider the mass spectrum of BCl_3 . How many peaks would be present, and what approximate mass would each peak correspond to in the BCl_3 mass spectrum?

137. A given sample of a xenon fluoride compound contains molecules of the type XeF_n , where n is some whole number. Given that 9.03×10^{20} molecules of XeF_n weigh 0.368 g, determine the value for n in the formula.

138. Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed as NutraSweet. The molecular formula of aspartame is $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5$.

- a. Calculate the molar mass of aspartame.
- b. What amount (moles) of molecules are present in 10.0 g aspartame?
- c. Calculate the mass in grams of 1.56 mole of aspartame.
- d. What number of molecules are in 5.0 mg aspartame?
- e. What number of atoms of nitrogen are in 1.2 g aspartame?
- f. What is the mass in grams of 1.0×10^9 molecules of aspartame?
- g. What is the mass in grams of one molecule of aspartame?

139. Anabolic steroids are performance enhancement drugs whose use has been banned from most major sporting activities. One anabolic steroid is fluoxymesterone ($C_{20}H_{29}FO_3$). Calculate the percent composition by mass of fluoxymesterone.
140. In the spring of 1984, concern arose over the presence of ethylene dibromide, or EDB, in grains and cereals. EDB has the molecular formula $C_2H_4Br_2$ and until 1984 was commonly used as a plant fumigant. The federal limit for EDB in finished cereal products is 30.0 parts per billion (ppb), where $1.0 \text{ ppb} = 1.0 \times 10^{-9} \text{ g}$ of EDB for every 1.0 g of sample. How many molecules of EDB are in 1.0 lb of flour if 30.0 ppb of EDB is present?
141. You find a compound composed only of element X and chlorine, and you know that the compound is 13.10% X by mass. Each molecule of the compound contains six times as many chlorine atoms as X atoms. What is element X?
142. What mass of sodium hydroxide has the same number of oxygen atoms as 100.0 g of ammonium carbonate?
143. The compound adrenaline contains 56.79% C, 6.56% H, 28.37% O, and 8.28% N by mass. What is the empirical formula for adrenaline?
144. Adipic acid is an organic compound composed of 49.31% C, 43.79% O, and the rest hydrogen. If the molar mass of adipic acid is 146.1 g/mol, what are the empirical and molecular formulas for adipic acid?
145. Vitamin B₁₂, cyanocobalamin, is essential for human nutrition. It is concentrated in animal tissue but not in higher plants. Although nutritional requirements for the vitamin are quite low, people who abstain completely from animal products may develop a deficiency anemia. Cyanocobalamin is the form used in vitamin supplements. It contains 4.34% cobalt by mass. Calculate the molar mass of cyanocobalamin, assuming that there is one atom of cobalt in every molecule of cyanocobalamin.
146. Some bismuth tablets, a medication used to treat upset stomachs, contain 262 mg of bismuth subsalicylate, $C_7H_5BiO_4$, per tablet. Assuming two tablets are digested, calculate the mass of bismuth consumed.
147. The empirical formula of styrene is CH; the molar mass of styrene is 104.14 g/mol. What number of H atoms are present in a 2.00-g sample of styrene?
148. Terephthalic acid is an important chemical used in the manufacture of polyesters and plasticizers. It contains only C, H, and O. Combustion of 19.81 mg terephthalic acid produces 41.98 mg CO_2 and 6.45 mg H_2O . If 0.250 mole of terephthalic acid has a mass of 41.5 g, determine the molecular formula for terephthalic acid.
149. A sample of a hydrocarbon (a compound consisting of only carbon and hydrogen) contains 2.59×10^{23} atoms of hydrogen and is 17.3% hydrogen by mass. If the molar mass of the hydrocarbon is between 55 and 65 g/mol, what amount (moles) of compound is present, and what is the mass of the sample?
150. A binary compound between an unknown element E and hydrogen contains 91.27% E and 8.73% H by mass. If the formula of the compound is E_3H_8 , calculate the atomic mass of E.
151. A 0.755-g sample of hydrated copper(II) sulfate

$$CuSO_4 \cdot xH_2O$$
 was heated carefully until it had changed completely to anhydrous copper(II) sulfate ($CuSO_4$) with a mass of 0.483 g. Determine the value of x . [This number is called the *number of waters of hydration* of copper(II) sulfate. It specifies the number of water molecules per formula unit of $CuSO_4$ in the hydrated crystal.]
152. ABS plastic is a tough, hard plastic used in applications requiring shock resistance. The polymer consists of three monomer units: acrylonitrile (C_3H_3N), butadiene (C_4H_6), and styrene (C_8H_8).
- a. A sample of ABS plastic contains 8.80% N by mass. It took 0.605 g of Br_2 to react completely with a 1.20-g sample of ABS plastic. Bromine reacts 1:1 (by moles) with the butadiene molecules in the polymer and nothing else. What is the percent by mass of acrylonitrile and butadiene in this polymer?
- b. What are the relative numbers of each of the monomer units in this polymer?
153. A sample of LSD (D-lysergic acid diethylamide, $C_{24}H_{30}N_2O$) is added to some table salt (sodium chloride) to form a mixture. Given that a 1.00-g sample of the mixture undergoes combustion to produce 1.20 g of CO_2 , what is the mass percent of LSD in the mixture?
154. Methane (CH_4) is the main component of marsh gas. Heating methane in the presence of sulfur produces carbon disulfide and hydrogen sulfide as the only products.
- a. Write the balanced chemical equation for the reaction of methane and sulfur.
- b. Calculate the theoretical yield of carbon disulfide when 120. g of methane is reacted with an equal mass of sulfur.
155. A potential fuel for rockets is a combination of B_3H_9 and O_2 . The two react according to the following balanced equation:
- $$2B_3H_9(l) + 12O_2(g) \longrightarrow 5B_2O_3(s) + 9H_2O(g)$$
- If one tank in a rocket holds 126 g B_3H_9 and another tank holds 192 g O_2 , what mass of water can be produced when the entire contents of each tank react together?
156. A 0.4230-g sample of impure sodium nitrate was heated, converting all the sodium nitrate to 0.2864 g of sodium nitrite and oxygen gas. Determine the percent of sodium nitrate in the original sample.
157. An iron ore sample contains Fe_2O_3 plus other impurities. A 752-g sample of impure iron ore is heated with excess carbon, producing 453 g of pure iron by the following reaction:
- $$Fe_2O_3(s) + 3C(s) \longrightarrow 2Fe(s) + 3CO(g)$$
- What is the mass percent of Fe_2O_3 in the impure iron ore sample? Assume that Fe_2O_3 is the only source of iron and that the reaction is 100% efficient.
158. Commercial brass, an alloy of Zn and Cu, reacts with hydrochloric acid as follows:
- $$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$$
- (Cu does not react with HCl.) When 0.5065 g of a certain brass alloy is reacted with excess HCl, 0.0985 g $ZnCl_2$ is eventually isolated.
- a. What is the composition of the brass by mass?
- b. How could this result be checked without changing the above procedure?