Pearson

# Exercises

## Review Questions

1. Explain this statement in your own words and give an example. *The properties of the substances around us depend on the structure of the particles that compose them.*
2. Explain the main goal of chemistry.
3. What are two different ways to classify matter?
4. How do solids, liquids, and gases differ?
5. Explain the difference between a pure substance and a mixture based on the composite particles of each.
6. Explain the difference between an element and a compound.
7. Explain the difference between a homogeneous and a heterogeneous mixture.
8. Describe the scientific approach to knowledge. How does it differ from other approaches?
9. Explain the differences between a hypothesis, a law, and a theory.
10. What observations did Antoine Lavoisier make? What law did he formulate?
11. What theory did John Dalton formulate?
12. What is wrong with the expression, "That is just a theory," if by theory the speaker is referring to a scientific theory?
13. Summarize the history of the atomic idea. How was Dalton able to convince others to accept an idea that had been controversial for 2000 years?
14. State and explain the law of conservation of mass.
15. State and explain the law of definite proportions.
16. State and explain the law of multiple proportions. How is the law of multiple proportions different from the law of definite proportions?
17. What are the main ideas in Dalton's atomic theory? How do they help explain the laws of conservation of mass, of constant composition, and of definite proportions?
18. How and by whom was the electron discovered? What basic properties of the electron were reported with its discovery?
19. Explain Millikan's oil drop experiment and how it led to the measurement of the electron's charge. Why is the magnitude of the charge of the electron so important?
20. Describe the plum-pudding model of the atom.
21. Describe Rutherford's gold foil experiment. How did the experiment prove that the plum-pudding model of the atom was wrong?
22. Describe Rutherford's nuclear model of the atom. What was revolutionary about his model?
23. If matter is mostly empty space, as suggested by Rutherford, then why does it appear so solid?
24. List the three subatomic particles that compose atoms and give the basic properties (mass and charge) of each.
25. What defines an element?
26. Explain the difference between $Z$ (the atomic number) and $A$ (the mass number).
27. Where do elements get their names?
28. What are isotopes? What is percent natural abundance of isotopes?
29. Describe the two different notations used to specify isotopes and give an example of each.
30. What is an ion? A cation? An anion?
31. What is atomic mass? How is it calculated?
32. Explain how a mass spectrometer works. What kind of information can be determined from a mass spectrum?
33. What is a mole? How is the mole concept useful in chemical calculations?
34. Why is the mass corresponding to a mole of one element different from the mass corresponding to a mole of another element?

## Problems by Topic

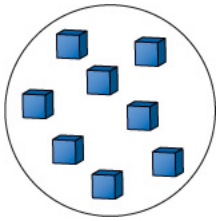
## Problems by Topic

*Note: Answers to all odd-numbered Problems can be found in Appendix III. Exercises in the Problems by Topic section are paired, with each odd-numbered problem followed by a similar even-numbered problem. Exercises in the Cumulative Problems section are also paired but more loosely. Because of their nature, Challenge Problems and Conceptual Problems are unpaired.*

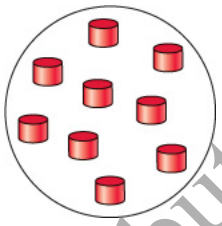
### The Classification of Matter

**35.** Each shape represents a type of particle (such as an atom or a molecule). Classify each image as a pure substance, homogeneous mixture, or heterogeneous mixture.

**a.**



**b.**



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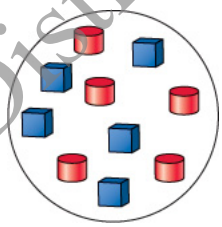
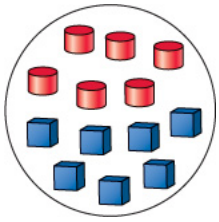


**d.**





**36.** Using triangles to represent one type of atom and circles to represent another type of atom, draw one image to represent a mixture of the two atoms and draw another image to represent a compound composed of the two atoms.

**37.** Classify each substance as a pure substance or a mixture. If it is a pure substance, classify it as an element or a compound. If it is a mixture, classify it as homogeneous or heterogeneous.

**a.** sweat

**b.** carbon dioxide

**c.** aluminum

**d.** vegetable soup

**38.** Classify each substance as a pure substance or a mixture. If it is a pure substance, classify it as an element or a compound. If it is a mixture, classify it as homogeneous or heterogeneous.

**a.** wine

**b.** beef stew

**c.** iron

**d.** carbon monoxide

**39.** Complete the table.

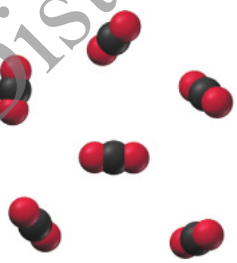
| Substance | Pure or mixture | Type |
|---|---|---|
| aluminum | pure | element |
| apple juice | _____ | _____ |
| hydrogen peroxide | _____ | _____ |
| chicken soup | _____ | _____ |

**40.** Complete the table.

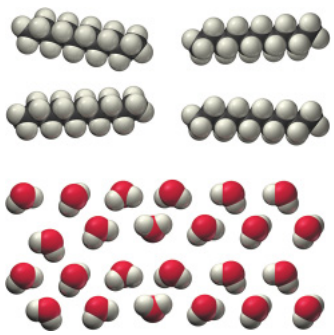
| Substance | Pure or mixture | Type |
|---|---|---|
| water | pure | compound |
| coffee | _____ | _____ |
| ice | _____ | _____ |
| carbon | _____ | _____ |

**41.** Determine whether each molecular diagram represents a pure substance or a mixture. If it represents a pure substance, classify the substance as an element or a compound. If it represents a mixture, classify the mixture as homogeneous or heterogeneous.

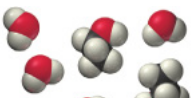
**a.**

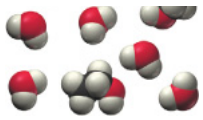


**b.**



**c.**

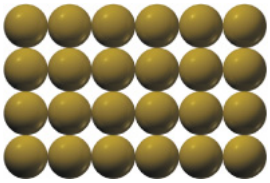




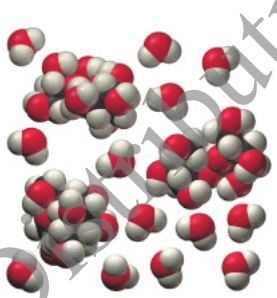
**d.**

**42.** Determine whether each molecular diagram represents a pure substance or a mixture. If it represents a pure substance, classify the substance as an element or a compound. If it represents a mixture, classify the mixture as homogeneous or heterogeneous.

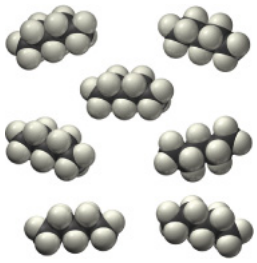
**a.**



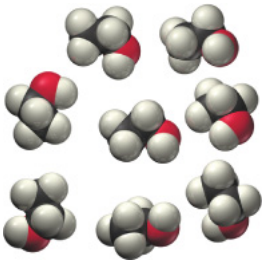
**b.**



**c.**



**d.**



## The Scientific Approach to Knowledge

**43.** Classify each statement as an observation, a law, or a theory.

**a.** All matter is made of tiny, indestructible particles called atoms.

**b.** When iron rusts in a closed container, the mass of the container and its contents do not change.

**c.** In chemical reactions, matter is neither created nor destroyed.

**d.** When a match burns, heat is released.

**44.** Classify each statement as an observation, a law, or a theory.

**a.** Chlorine is a highly reactive gas.

**b.** If elements are listed in order of increasing mass of their atoms, their chemical reactivity follows a repeating pattern.

**c.** Neon is an inert (or nonreactive) gas.

**d.** The reactivity of elements depends on the arrangement of their electrons.

**45.** A chemist decomposes several samples of carbon monoxide into carbon and oxygen and weighs the resulting elements. The results are shown in the table.

| Sample | Mass of Carbon (g) | Mass of Oxygen (g) |
|---|---|---|
| 1 | 6 | 8 |
| 2 | 12 | 16 |
| 3 | 18 | 24 |

**a.** Describe any pattern you notice in these results.

Next, the chemist decomposes several samples of hydrogen peroxide into hydrogen and oxygen. The results are shown in the table.

| Sample | Mass of Hydrogen (g) | Mass of Oxygen (g) |
|---|---|---|
| 1 | 0.5 | 8 |
| 2 | 1 | 16 |
| 3 | 1.5 | 24 |

**b.** Describe any similarity you notice between these results and those for carbon monoxide in part a.

**c.** Can you formulate a law from the observations in a and b?

**d.** Can you formulate a hypothesis that might explain your law in c?

**46.** When astronomers observe distant galaxies, they can tell that most of them are moving away from one another. In addition, the more distant the galaxies, the more rapidly they are likely to be moving away from each other. Can you devise an hypothesis to explain these observations?



## The Laws of Conservation of Mass, Definite Proportions, and Multiple Proportions

**47.** A hydrogen-filled balloon is ignited and 1.50 g of hydrogen reacts with 12.0 g of oxygen. How many grams of water vapor form? (Assume that water vapor is the only product.)

**48.** An automobile gasoline tank holds 21 kg of gasoline. When the gasoline burns, 84 kg of oxygen is consumed, and carbon dioxide and water are produced. What is the total combined mass of carbon dioxide and water that is produced?

**49.** Two samples of carbon tetrachloride are decomposed into their constituent elements. One sample produces 38.9 g of carbon and 448 g of chlorine, and the other sample produces 14.8 g of carbon and 134 g of chlorine. Are these results consistent with the law of definite proportions? Show why or why not.

**50.** Two samples of sodium chloride are decomposed into their constituent elements. One sample produces 6.98 g of sodium and 10.7 g of chlorine, and the other sample produces 11.2 g of sodium and 17.3 g of chlorine. Are these results consistent with the law of definite proportions? Explain your answer.

**51.** The mass ratio of sodium to fluorine in sodium fluoride is 1.21:1. A sample of sodium fluoride produces 28.8 g of sodium upon decomposition. How much fluorine (in grams) is formed?

**52.** Upon decomposition, one sample of magnesium fluoride produces 1.65 kg of magnesium and 2.57 kg of

fluorine. A second sample produces 1.32 kg of magnesium. How much fluorine (in grams) does the second sample produce?

**53.** Two different compounds containing osmium and oxygen have the following masses of oxygen per gram of osmium: 0.168 and 0.3369 g. Show that these amounts are consistent with the law of multiple proportions.

**54.** Palladium forms three different compounds with sulfur. The mass of sulfur per gram of palladium in each compound is listed in the accompanying table.

| Compound | Grams S per Gram Pd |
|---|---|
| A | 0.603 |
| B | 0.301 |
| C | 0.151 |

Show that these masses are consistent with the law of multiple proportions.

**55.** Sulfur and oxygen form both sulfur dioxide and sulfur trioxide. When samples of these are decomposed, the sulfur dioxide produces 3.49 g oxygen and 3.50 g sulfur, while the sulfur trioxide produces 6.75 g oxygen and 4.50 g sulfur. Calculate the mass of oxygen per gram of sulfur for each sample and show that these results are consistent with the law of multiple proportions.

**56.** Sulfur and fluorine form several different compounds including sulfur hexafluoride and sulfur tetrafluoride. Decomposition of a sample of sulfur hexafluoride produces 4.45 g of fluorine and 1.25 g of sulfur, while decomposition of a sample of sulfur tetrafluoride produces 4.43 g of fluorine and 1.87 g of sulfur. Calculate the mass of fluorine per gram of sulfur for each sample and show that these results are consistent with the law of multiple proportions.

## Atomic Theory, Nuclear Theory, and Subatomic Particles

**57.** Which statements are *consistent* with Dalton's atomic theory as it was originally stated? Why?

**a.** Sulfur and oxygen atoms have the same mass.

**b.** All cobalt atoms are identical.

**c.** Potassium and chlorine atoms combine in a 1:1 ratio to form potassium chloride.

**d.** Lead atoms can be converted into gold.

**58.** Which statements are *inconsistent* with Dalton's atomic theory as it was originally stated? Why?

**a.** All carbon atoms are identical.

**b.** An oxygen atom combines with 1.5 hydrogen atoms to form a water molecule.

**c.** Two oxygen atoms combine with a carbon atom to form a carbon dioxide molecule.

**d.** The formation of a compound often involves the destruction of one or more atoms.

**59.** Which statements are *consistent* with Rutherford's nuclear theory as it was originally stated? Why?

**a.** The volume of an atom is mostly empty space.

**b.** The nucleus of an atom is small compared to the size of the atom.

**c.** Neutral lithium atoms contain more neutrons than protons.

**d.** Neutral lithium atoms contain more protons than electrons.

**60.** Which statements are *inconsistent* with Rutherford's nuclear theory as it was originally stated? Why?

**a.** Since electrons are smaller than protons, and since a hydrogen atom contains only one proton and one electron, it must follow that the volume of a hydrogen atom is mostly due to the proton.

**b.** A nitrogen atom has 7 protons in its nucleus and 7 electrons outside of its nucleus.

**c.** A phosphorus atom has 15 protons in its nucleus and 150 electrons outside of its nucleus.

**d.** The majority of the mass of a fluorine atom is due to its 9 electrons.

**61.** A chemist in an imaginary universe, where electrons have a different charge than they do in our universe, performs the Millikan oil drop experiment to measure the electron's charge. The charges of several drops are recorded here. What is the charge of the electron in this imaginary universe?

| Drop # | Charge |
|---|---|
| A | $-6.9 \times 10^{-19}$ C |
| B | $-9.2 \times 10^{-19}$ C |
| C | $-11.5 \times 10^{-19}$ C |
| D | $-4.6 \times 10^{-19}$ C |

−4.6 × 10 C

**62.** Imagine a unit of charge called the zorg. A chemist performs the Millikan oil drop experiment and measures the charge of each drop in zorgs. Based on the results shown here, what is the charge of the electron in zorgs (z)? How many electrons are in each drop?

| Drop # | Charge |
|---|---|
| A | $-4.8 \times 10^{-9}$ z |
| B | $-9.6 \times 10^{-9}$ z |
| C | $-6.4 \times 10^{-9}$ z |
| D | $-12.8 \times 10^{-9}$ z |

**63.** Which statements about subatomic particles are true?

**a.** If an atom has an equal number of protons and electrons, it will be charge-neutral.

**b.** Electrons are attracted to protons.

**c.** Electrons are much lighter than neutrons.

**d.** Protons have twice the mass of neutrons.

**64.** Which statements about subatomic particles are false?

**a.** Protons and electrons have charges of the same magnitude but opposite sign.

**b.** Protons have about the same mass as neutrons.

**c.** Some atoms don't have any protons.

**d.** Protons and neutrons have charges of the same magnitude but opposite signs.

## Isotopes and Ions

**65.** Write isotopic symbols in the form *X*–*A* (e.g., C-13) for each isotope.

**a.** the silver isotope with 60 neutrons

**b.** the silver isotope with 62 neutrons

**c.** the uranium isotope with 146 neutrons

**d.** the hydrogen isotope with 1 neutron

**66.** Write isotopic symbols in the form ${}^{A}_{Z}X$ for each isotope.

**a.** the copper isotope with 34 neutrons

**b.** the copper isotope with 36 neutrons

**c.** the potassium isotope with 21 neutrons

**d.** the argon isotope with 22 neutrons

**67.** Determine the number of protons and the number of neutrons in each isotope.

**a.** ${}^{14}_{7}\mathrm{N}$

**b.** ${}^{23}_{11}\mathrm{Na}$

**c.** ${}^{222}_{86}\mathrm{Rn}$

**d.** ${}^{208}_{82}\mathrm{Pb}$

**68.** Determine the number of protons and the number of neutrons in each isotope.

**a.** ${}^{40}_{19}\mathrm{K}$

**b.** ${}^{226}_{88}\mathrm{Ra}$

**c.** ${}^{99}_{43}\mathrm{Tc}$

**d.** ${}^{33}_{15}\mathrm{P}$

**69.** The amount of carbon-14 in ancient artifacts and fossils is often used to establish their age. Determine the number of protons and the number of neutrons in a carbon-14 isotope and write its symbol in the form ${}^{A}_{Z}\mathrm{X}$.

**70.** Uranium-235 is used in nuclear fission. Determine the number of protons and the number of neutrons in uranium-235 and write its symbol in the form ${}^{A}_{Z}\mathrm{X}$.

**71.** Determine the number of protons and the number of electrons in each ion.

**a.** $\mathrm{Ni}^{2+}$

**b.** $\mathrm{S}^{2-}$

**c.** $\mathrm{Br}^{-}$

**d.** $\mathrm{Cr}^{3+}$

72. Determine the number of protons and the number of electrons in each ion.

a. $Al^{3+}$

b. $Se^{2-}$

c. $Ga^{3+}$

d. $Sr^{2+}$

## Atomic Mass and Mass Spectrometry

73. Gallium has two naturally occurring isotopes with the following masses and natural abundances:

| Isotope | Mass (amu) | Abundance (%) |
|---|---|---|
| Ga-69 | 68.92558 | 60.108 |
| Ga-71 | 70.92470 | 39.892 |

Sketch the mass spectrum of gallium.

74. Magnesium has three naturally occurring isotopes with the following masses and natural abundances:

| Isotope | Mass (amu) | Abundance (%) |
|---|---|---|
| Mg-24 | 23.9850 | 78.99 |
| Mg-25 | 24.9858 | 10.00 |
| Mg-26 | 25.9826 | 11.01 |

Sketch the mass spectrum of magnesium.

75. The atomic mass of fluorine is 18.998 amu, and its mass spectrum shows a large peak at this mass. The atomic mass of chlorine is 35.45 amu, yet the mass spectrum of chlorine does not show a peak at this mass. Explain the difference.

76. The atomic mass of copper is 63.546 amu. Do any copper isotopes have a mass of 63.546 amu? Explain.

77. An element has two naturally occurring isotopes. Isotope 1 has a mass of 120.9038 amu and a relative abundance of 57.4%, and isotope 2 has a mass of 122.9042 amu. Find the atomic mass of this element and identify it.

78. An element has four naturally occurring isotopes with the masses and natural abundances given here. Find the atomic mass of the element and identify it.

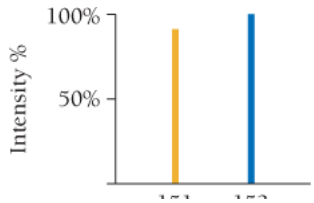
| Isotope | Mass (amu) | Abundance (%) |
|---|---|---|
| 1 | 135.90714 | 0.19 |
| 2 | 137.90599 | 0.25 |
| 3 | 139.90543 | 88.43 |
| 4 | 141.90924 | 11.13 |



79. Bromine has two naturally occurring isotopes (Br-79 and Br-81) and an atomic mass of 79.904 amu. The mass of Br-81 is 80.9163 amu, and its natural abundance is 49.31%. Calculate the mass and natural abundance of Br-79.

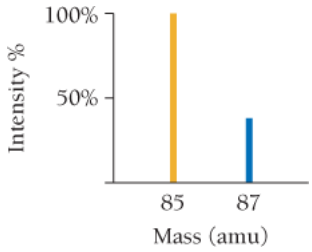
80. Silicon has three naturally occurring isotopes (Si-28, Si-29, and Si-30). The mass and natural abundance of Si-28 are 27.9769 amu and 92.2%, respectively. The mass and natural abundance of Si-29 are 28.9765 amu and 4.67%, respectively. Find the mass and natural abundance of Si-30.

81. Use the mass spectrum of europium shown here to determine the atomic mass of europium.



151 153
Mass (amu)

**82.** Use the mass spectrum of rubidium shown here to determine the atomic mass of rubidium.




## The Mole Concept

**83.** How many sulfur atoms are there in 5.52 mol of sulfur?

**84.** How many moles of aluminum do $3.7 \times 10^{24}$ aluminum atoms represent?

**85.** What is the amount, in moles, of each elemental sample?

**a.** 11.8 g Ar

**b.** 3.55 g Zn

**c.** 26.1 g Ta

**d.** 0.211 g Li

**86.** What is the mass, in grams, of each elemental sample?

**a.** $2.3 \times 10^{3}$ mol Sb

**b.** 0.0355 mol Ba

**c.** 43.9 mol Xe

**d.** 1.3 mol W

**87.** How many silver atoms are there in 3.78 g of silver?

**88.** What is the mass of $4.91 \times 10^{21}$ platinum atoms?

**89.** Calculate the number of atoms in each sample.

**a.** 5.18 g P

**b.** 2.26 g Hg

**c.** 1.87 g Bi

**d.** 0.082 g Sr

**90.** Calculate the number of atoms in each sample.

**a.** 14.955 g Cr

**b.** 39.733 g S

**c.** 12.899 g Pt

**d.** 97.552 g Sn

**91.** Calculate the mass, in grams, of each sample.

**a.** $1.1 \times 10^{23}$ gold atoms

**b.** $2.82 \times 10^{22}$ helium atoms

**c.** $1.8 \times 10^{23}$ lead atoms

**d.** $7.9 \times 10^{21}$ uranium atoms

**92.** Calculate the mass, in kg, of each sample.

**a.** $7.55 \times 10^{26}$ cadmium atoms

**b.** $8.15 \times 10^{27}$ nickel atoms

**c.** $1.22 \times 10^{27}$ manganese atoms

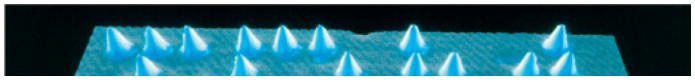
**d.** $5.48 \times 10^{29}$ lithium atoms

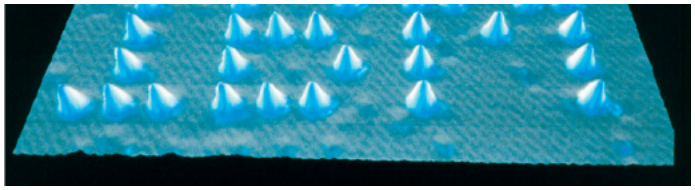
**93.** How many carbon atoms are there in a diamond (pure carbon) with a mass of 52 mg?

**94.** How many helium atoms are there in a helium blimp containing 536 kg of helium?

**95.** Calculate the average mass, in grams, of one platinum atom.

**96.** Using scanning tunneling microscopy, scientists at IBM wrote the initials of their company with 35 individual xenon atoms (as shown below). Calculate the total mass of these letters in grams.





## Cumulative Problems

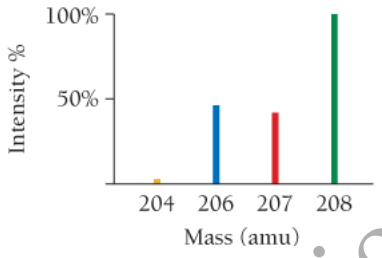
**97.** A 7.83-g sample of HCN contains 0.290 g of H and 4.06 g of N. Find the mass of carbon in a sample of HCN with a mass of 3.37 g.

**98.** The ratio of sulfur to oxygen by mass in $SO_2$ is 1.0:1.0.

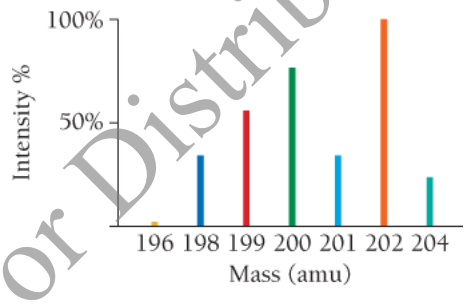
**a.** Find the ratio of sulfur to oxygen by mass in $SO_3$.

**b.** Find the ratio of sulfur to oxygen by mass in $S_2O$.

**99.** Use the mass spectrum of lead shown here to estimate the atomic mass of lead. Estimate the mass and percent intensity values from the graph to three significant figures.




**100.** Use the mass spectrum of mercury shown here to estimate the atomic mass of mercury. Estimate the masses and percent intensity values from the graph to three significant figures.




**101.** Nuclei with the same number of *neutrons* but different mass numbers are called *isotones*. Write the symbols of four isotones of $^{236}Th$.

**102.** Fill in the blanks to complete the table.

| Symbol | Z | A | Number of $p^+$ | Number of $e^-$ | Number of n | Charge |
|---|---|---|---|---|---|---|
| Si | 14 | ____ | ____ | 14 | 14 | ____ |
| $S^{2-}$ | ____ | 32 | ____ | ____ | ____ | 2− |
| $Cu^{2+}$ | ____ | ____ | ____ | ____ | 34 | 2+ |
| ____ | 15 | ____ | ____ | 15 | 16 | ____ |

**103.** A penny has a thickness of approximately 1.0 mm. If you stacked Avogadro's number of pennies one on top of the other on Earth's surface, how far would the stack extend (in km)? For comparison, the sun is about 150 million km from Earth and the nearest star, Proxima Centauri, is about 40 trillion km from Earth.

**104.** Consider the stack of pennies in Problem 103. How much money (in dollars) would this represent? If this money were equally distributed among the world's population of 6.5 billion people, how much would each

person receive? Would each person be a millionaire? A billionaire? A trillionaire?

**105.** A pure copper sphere has a radius of 0.935 in. How many copper atoms does it contain? The volume of a sphere is $(4/3)\ \pi r^3$, and the density of copper is 8.96 $\mathrm{g/cm^3}$.

**106.** A pure titanium cube has an edge length of 2.78 in. How many titanium atoms does it contain? Titanium has a density of 4.50 $\mathrm{g/cm^3}$.

**107.** A 67.2-g sample of a gold and palladium alloy contains $2.49 \times 10^{23}$ atoms. What is the composition (by mass) of the alloy?

**108.** Common brass is a copper and zinc alloy containing 37.0% zinc by mass and having a density of 8.48 $\mathrm{g/cm^3}$. A fitting composed of common brass has a total volume of 112.5 $\mathrm{cm^3}$. How many atoms (copper and zinc) does the fitting contain?

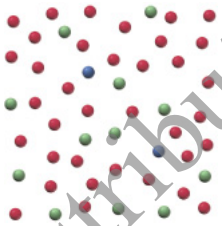
**109.** The U.S. Environmental Protection Agency (EPA) sets limits on healthful levels of air pollutants. The maximum level that the EPA considers safe for lead air pollution is 1.5 $\mu g/\mathrm{m^3}$. If your lungs were filled with air containing this level of lead, how many lead atoms would be in your lungs? (Assume a total lung volume of 5.50 L.)

**110.** Pure gold is usually too soft for jewelry, so it is often alloyed with other metals. How many gold atoms are in a 0.255-ounce 18 K gold bracelet? (18 K gold is 75% gold by mass.)

## Challenge Problems

**111.** Silver is composed of two naturally occurring isotopes: Ag-107 (51.839%) and Ag-109. The ratio of the masses of the two isotopes is 1.0187. What is the mass of Ag-107?

**112.** To the right is a representation of 50 atoms of a fictitious element called westmontium (Wt). The red spheres represent Wt-296, the blue spheres Wt-297, and the green spheres Wt-298.



**a.** Assuming that the sample is statistically representative of a naturally occurring sample, calculate the percent natural abundance of each Wt isotope.

**b.** Draw the mass spectrum for a naturally occurring sample of Wt.

**c.** The mass of each Wt isotope is measured relative to C-12 and tabulated here. Use the mass of C-12 to convert each of the masses to amu and calculate the atomic mass of Wt.

| Isotope | Mass |
|---|---|
| Wt-296 | 24.6630 × Mass($^{12}$C) |
| Wt-297 | 24.7490 × Mass($^{12}$C) |
| Wt-298 | 24.8312 × Mass($^{12}$C) |



**113.** The ratio of oxygen to nitrogen by mass in $NO_2$ is 2.29. The ratio of fluorine to nitrogen by mass in $NF_3$ is 4.07. Find the ratio of oxygen to fluorine by mass in $OF_2$.

**114.** Naturally occurring cobalt consists of only one isotope, $^{59}$Co, whose relative atomic mass is 58.9332. A synthetic radioactive isotope of cobalt, $^{60}$Co, relative atomic mass 59.9338, is used in radiation therapy for cancer. A 1.5886-g sample of cobalt has an apparent "atomic mass" of 58.9901. Find the mass of $^{60}$Co in this sample.

**115.** A 7.36-g sample of copper is contaminated with an additional 0.51 g of zinc. Suppose an atomic mass measurement is performed on this sample. What would be the apparent measured atomic mass?

**116.** The ratio of the mass of O to the mass of N in $N_2O_3$ is 12:7. Another binary compound of nitrogen has a ratio of O to N of 16:7. What is its formula? What is the ratio of O to N in the next member of this series of compounds?

**117.** Naturally occurring magnesium has an atomic mass of 24.312 and consists of three isotopes. The major isotope

**117.** Naturally occurring magnesium has an atomic mass of 24.312 and consists of three isotopes. The major isotope is $^{24}Mg$, natural abundance 78.99%, relative atomic mass 23.98504. The next most abundant isotope is $^{26}Mg$, relative atomic mass 25.98259. The third most abundant isotope is $^{25}Mg$ whose natural abundance is in the ratio of 0.9083 to that of $^{26}Mg$. Find the relative atomic mass of $^{25}Mg$.

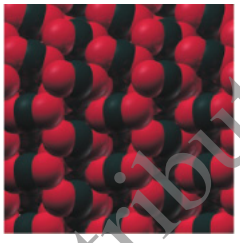
**118.** In Section 1.10, it was stated that 1 mol of sand grains would cover the state of Texas to several feet. Estimate how many feet by assuming that the sand grains are roughly cube-shaped, each one with an edge length of 0.10 mm. Texas has a land area of 268,601 sq mi.

**119.** Use the concepts in this chapter to obtain an estimate for the number of atoms in the universe. Make the following assumptions: **(a)** All of the atoms in the universe are hydrogen atoms in stars. (This is not a ridiculous assumption because over three-fourths of the atoms in the universe are in fact hydrogen. Gas and dust between the stars represent only about 15% of the visible matter of our galaxy, and planets compose a far smaller fraction.) **(b)** The sun is a typical star composed of pure hydrogen with a density of $1.4\ g/cm^3$ and a radius of $7 \times 10^8$ m. **(c)** Each of the roughly 100 billion stars in the Milky Way galaxy contains the same number of atoms as our sun. **(d)** Each of the 10 billion galaxies in the visible universe contains the same number of atoms as our Milky Way galaxy.

## Conceptual Problems

**120.** A volatile liquid (one that readily evaporates) is put into a jar, and the jar is then sealed. Does the mass of the sealed jar and its contents change upon the vaporization of the liquid?

**121.** The diagram to the right represents solid carbon dioxide, also known as dry ice.
Which of the diagrams below best represents the dry ice after it has sublimed into a gas?



**a.**

**b.**

**c.**

**122.** Use triangles to represent atoms of element A and circles to represent atoms of element B. Draw an atomic level view of a homogeneous mixture of elements A and B. Draw an atomic view of the compound AB in a

liquid state (molecules close together). Draw an atomic view of the compound AB after it has undergone a physical change (such as evaporation). Draw an atomic view of the compound after it has undergone a chemical change (such as decomposition of AB into A and B).

**123.** Identify each statement as being most like an observation, a law, or a theory.

**a.** All coastal areas experience two high tides and two low tides each day.

**b.** The tides in Earth's oceans are caused mainly by the gravitational attraction of the moon.

**c.** Yesterday, high tide in San Francisco Bay occurred at 2:43 A.M. and 3:07 P.M.

**d.** Tides are higher at the full moon and new moon than at other times of the month.

**124.** The mole is defined as the amount of a substance containing the same number of particles as exactly 12 g of C-12. The amu is defined as 1/12 of the mass of an atom of C-12. Why is it important that both of these definitions reference the same isotope? What would be the result, for example, of defining the mole with respect to C-12, but the amu with respect to Ne-20?

**125.** Without doing any calculations, determine which of the samples contains the greatest amount of the element in moles. Which contains the greatest mass of the element?

**a.** 55.0 g Cr

**b.** 45.0 g Ti

**c.** 60.0 g Zn

## Questions for Group Work

### Active Classroom Learning

Discuss these questions with the group and record your consensus answer.

**126.** Using white and black circles to represent different kinds of atoms, make a drawing that accurately represents each sample of matter: a solid element, a liquid compound, and a heterogeneous mixture. Make a drawing (clearly showing *before* and *after*) depicting your liquid compound undergoing a physical change. Make a drawing depicting your solid element undergoing a chemical change.

**127.** In a naturally occurring sample, 19.8% of boron atoms have 5 neutrons and 80.2% have 6 neutrons. What is the mass number of each boron isotope? Sketch a sample of 10 atoms that is nearly representative of a natural sample. What is the average mass of the atoms in your drawing? What is the atomic mass of boron? (Boron-10 has a mass of 10.01294 amu, and boron-11 has a mass of 11.00931 amu.)

**128.** In complete sentences, describe the similarities and differences between:

**a.** different isotopes of an element

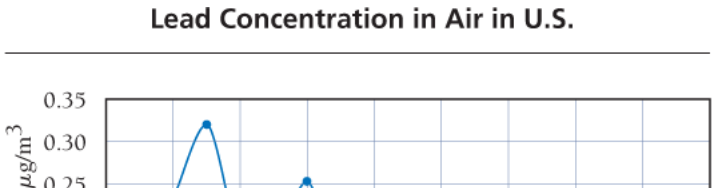
**b.** a neutral atom and an ion of the same element

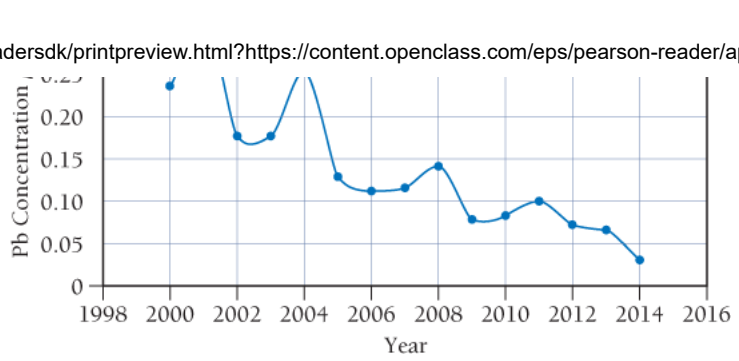
**129.** Calculate the mass in grams of one mole of each of the following (the mass of a single item is given in parentheses): electrons $(9.10938 \times 10^{-28}\text{g})$, protons $(1.67262 \times 10^{-24}\text{g})$, neutrons $(1.67493 \times 10^{-24}\text{g})$, atoms of carbon-12 $(1.992646 \times 10^{-23}\text{g})$, and doughnuts (74 g). Compare the mass of one mole of carbon-12 atoms to the sum of the masses of the particles that it contains. If the doughnut mentioned in this question were made entirely of carbon, how many atoms would it contain?



## Data Interpretation and Analysis

**130.** The U.S. Environmental Protection Agency (U.S. EPA) monitors air quality in the United States. Lead is among the pollutants regularly monitored and regulated. Lead is released into the atmosphere primarily by the processing of metals ores containing lead and by lead-based battery manufacturing. The effects of too much exposure to lead include neurological damage and cardiovascular disease. Because of the Clean Air Act and its amendments, the amounts of lead in air have been decreasing for many years. The chart below shows the lead concentration in air in the United States from 2000 to 2014. Examine the data and answer the questions below.





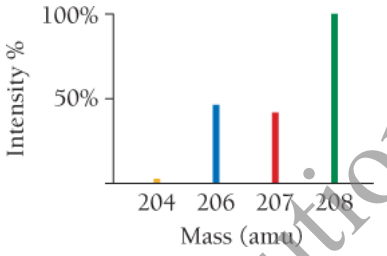

Determine the lead concentrations in 2000 and in 2014.

Calculate the percent change in lead concentration that occurred from 2000 to 2014. *Hint*: Calculate the percent change with the following equation:

$$\text{percent change} = \frac{(\text{final concentration} - \text{initial concentration})}{\text{initial concentration}} \times 100\%$$

How many lead atoms were in one cubic centimeter of air in 2011?

Examine the mass spectrum for lead shown below. How many Pb-206 atoms were in one cubic centimeter of air in 2011?

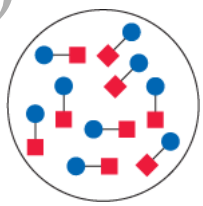




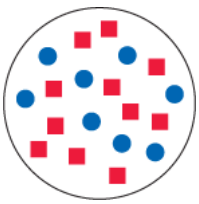

## Answers to Conceptual Connections

**Cc 1.1**

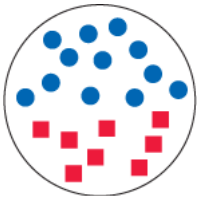
**a.**



**b.**



**c.**



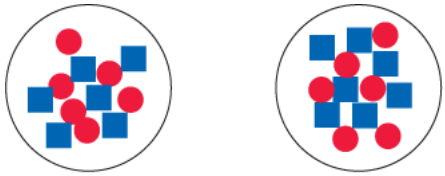
**Cc 1.2** **(b)** A law only summarizes a series of related observations, whereas a theory gives the underlying reasons for them.

**Cc 1.3** Most of the matter that composed the log reacts with oxygen molecules in the air. The products of the reaction (mostly carbon dioxide and water) are released as gases into the air.

**Cc 1.4** The law of definite proportions applies to two or more samples of the *same compound* and states that the ratio of one element to the other is always the same. The law of multiple proportions applies to two *different compounds* containing the same two elements (A and B) and states that the masses of B that combine with 1 g of A are always related to each other as a small whole-number ratio.

**Cc 1.5** The drop contains three excess electrons $\left(3 \times \left(-1.6 \times 10^{-19}\ \text{C}\right) = -4.8 \times 10^{-19}\ \text{C}\right)$.

**Cc 1.6**




A 10,000-atom sample of carbon, on average, contains 107 C-13 atoms.

**Cc 1.7** **(b)** The number of neutrons in the nucleus of an atom does not affect the atom's size because the nucleus is miniscule compared to the atom itself.

**Cc 1.8** **(a)** Since 98.93% of the atoms are C-12, we would expect the atomic mass to be very close to the mass of the C-12 isotope.

**Cc 1.9** **(b)** 1 g carbon contains the greatest number of atoms.