Chapter 2: Atoms and Molecules

CHAPTER OUTLINE

LEARNING OBJECTIVES/ASSESSMENT

When you have completed your study of this chapter, you should be able to:

1. Use symbols for chemical elements to write formulas for chemical compounds. (Section 2.1; Exercise 2.4)
2. Identify the characteristics of protons, neutrons, and electrons. (Section 2.2; Exercises 2.10 and 2.12)
3. Use the concepts of atomic number and mass number to determine the number of subatomic particles in isotopes and to write correct symbols for isotopes. (Section 2.3; Exercises 2.16 and 2.22)
4. Use atomic weights of the elements to calculate molecular weights of compounds. (Section 2.4; Exercise 2.32)
5. Use isotope percent abundances and masses to calculate atomic weights of the elements. (Section 2.5; Exercise 2.38)
6. Use the mole concept to obtain relationships between number of moles, number of grams, and number of atoms for elements, and use those relationships to obtain factors for use in factor-unit calculations. (Section 2.6; Exercises 2.44 a & b and 2.46 a & b)
7. Use the mole concept and molecular formulas to obtain relationships between number of moles, number of grams, and number of atoms or molecules for compounds, and use those relationships to obtain factors for use in factor-unit calculations. (Section 2.7; Exercise 2.50 b and 2.52 b)

LECTURE HINTS AND SUGGESTIONS

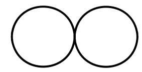
1. The word "element" has two usages: (1) a homoatomic, pure substance; and (2) a kind of atom. This dual usage confuses the beginning student. It often helps the beginning student for the instructor to distinguish the usage intended in a particular statement. e.g. "There are 112 elements, meaning 112 kinds of atoms." or "Each kind of atom (element) has a name and a symbol." or "Water contains the element (kind of atom) oxygen."
2. Emphasize that the term "molecule" can mean: (1) the limit of physical subdivision of a molecular compound; (2) the smallest piece of a molecular compound; or (3) the basic building block of which a molecular compound is made. Do not try to differentiate at this time the differences between ionic solids, molecular compounds, or network solids.
3. Many students fail to make a connection that a given pure substance has only one kind of constituent particle present; i.e., pure water contains only one kind of molecule, the water molecule. The molecule of water is made up of atoms of hydrogen and oxygen, but there are no molecules of hydrogen or oxygen in pure water.
4. The student will memorize the names and symbols for approximately one-third of the 112 elements to be dealt with-those commonly encountered in this course or in daily living. Mentioning both the name and the symbol whenever an element is mentioned in the lecture will aid the student's memorizing.
5. While memorization of the names and symbols is important, it should not become the major outcome of this class. Avoid reinforcing the mistaken notion that chemistry is merely learning formulas and equations.

6. It should be emphasized that the mole is a convenient way of measuring out needed numbers of atoms and molecules In the correct ratios for chemical reactions. Explain that the term "mole" is the same type of term as "dozen," "pair," or "gross," except that it specifies a much larger number of items.

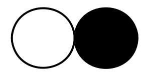
SOLUTIONS FOR THE END OF CHAPTER EXERCISES

SYMBOLS AND FORMULAS (SECTION 2.1)

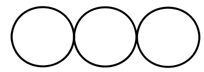
2.1 a. A diatomic molecule of an element*



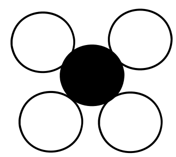
b. A diatomic molecule of a compound*



c. A triatomic molecule of an element

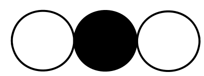


d. A molecule of a compound containing one atom of one element and four atoms of another element

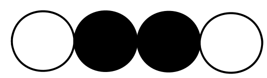


*Note: Each of these structures could be drawn in many different ways.

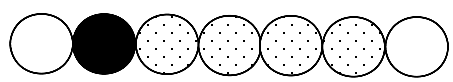
2.2 a. A triatomic molecule of a compound*



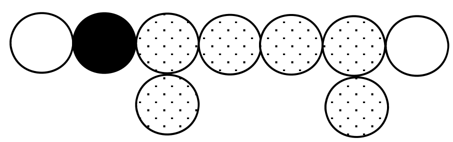
b. A molecule of a compound containing two atoms of one element and two atoms of a second element*



c. A molecule of a compound containing two atoms of one element, one atom of a second element, and four atoms of a third element*



d. A molecule containing two atoms of one element, six atoms of a second element, and one atom of a third element*



*Note: Each of these structures could be drawn in many different ways.

2.3 a. A diatomic molecule of chlorine gas (two chlorine atoms) — Cl_2; like Exercise 2.1 a

b. A diatomic molecule of hydrogen fluoride (one hydrogen atom and one fluorine atom) — HF; like Exercise 2.1 b

c. A triatomic molecule of ozone (three oxygen atoms) — O_3; like Exercise 2.1 c*

d. A molecule of carbon tetrachloride (one atom of carbon and four atoms of chlorine) — CCl_4; like Exercise 2.1 d*

*The number and variety of atoms are alike. The actual structures of the molecules are different.

☑2.4 a. A molecule of water (two hydrogen atoms and one oxygen atom) — H_2O; like Exercise 2.2 a*

b. A molecule of hydrogen peroxide (two hydrogen atoms and two oxygen atoms) — H_2O_2; like Exercise 2.2 b*

*The number and variety of atoms are alike. The actual structures of the molecules are different.

c. A molecule of sulfuric acid (two hydrogen atoms, one sulfur atom, and four oxygen atoms) — H_2SO_4; like Exercise 2.2 c*

d. A molecule of ethyl alcohol (two carbon atoms, six hydrogen atoms, and one oxygen atom) — C_2H_6O; like Exercise 2.2 d*

*The number and variety of atoms are alike. The actual structures of the molecules are different.

2.5	a.	ammonia (NH_3)	1 nitrogen atom; 3 hydrogen atoms
	b.	acetic acid ($C_2H_4O_2$)	2 carbon atoms; 4 hydrogen atoms; 2 oxygen atoms
	c.	boric acid (H_3BO_3)	3 hydrogen atoms; 1 boron atom; 3 oxygen atoms
	d.	ethane (C_2H_6)	2 carbon atoms; 6 hydrogen atoms
2.6	a.	Sulfur dioxide (SO_2)	1 sulfur atom; 2 oxygen atoms
	b.	Butane (C_4H_{10})	4 carbon atoms; 10 hydrogen atoms
	c.	Chlorous acid ($HClO_2$)	1 hydrogen atom; 1 chlorine atom; 2 oxygen atoms
	d.	Boron trifluoride (BF_3)	1 boron atom; 3 fluorine atoms
2.7	a.	H3PO3 (phosphorous acid)	The numbers should be subscripted: H_3PO_3
	b.	$SICl_4$ (silicon tetrachloride)	The elemental symbol for silicon is Si: $SiCl_4$
	c.	SOO (sulfur dioxide)	Only one O should be written and a subscript 2 should be added: SO_2
	d.	2HO (hydrogen peroxide—two hydrogen atoms and two oxygen atoms)	The number 2 should be a subscript after H and after O: H_2O_2
2.8	a.	HSH (hydrogen sulfide)	More than one H is part of the compound; a subscript should be used: H_2S
	b.	$HCLO_2$ (chlorous acid)	The elemental symbol for chlorine is Cl (the second letter of a symbol must be lowercase): $HClO_2$
	c.	$2HN_2$ (hydrazine – two hydrogen atoms and four nitrogen atoms)	The subscripts should reflect the actual number of each type of atom in the compound: H_2N_4
	d.	C2H6 (ethane)	The numbers should be subscripted: C_2H_6

INSIDE THE ATOM (SECTION 2.2)

2.9			**Charge**	**Mass (u)**
	a.	6 protons and 6 neutrons	6	12
	b.	8 protons and 9 neutrons	8	17
	c.	20 protons and 25 neutrons	20	45
	d.	52 protons and 78 neutrons	52	130

☑2.10			**Charge**	**Mass (u)**
	a.	4 protons and 5 neutrons	4	9
	b.	9 protons and 10 neutrons	9	19
	c.	20 protons and 23 neutrons	20	43
	d.	47 protons and 60 neutrons	47	107

2.11 The number of protons and electrons are equal in a neutral atom.

a. 5 electrons b. 10 electrons c. 18 electrons d. 50 electrons

☑2.12 The number of protons and electrons are equal in a neutral atom.

a. 4 electrons b. 9 electrons c. 20 electrons d. 47 electrons

ISOTOPES (SECTION 2.3)

2.13

		Electrons	Protons
a.	sulfur	16	16
b.	As	33	33
c.	element number 24	24	24

2.14

		Electrons	Protons
a.	silicon	14	14
b.	Sn	50	50
c.	element number 74	74	74

2.15

		Protons	Neutrons	Electrons
a.	$^{3}_{2}He$	2	1	2
b.	$^{9}_{4}Be$	4	5	4
c.	$^{235}_{92}U$	92	143	92

☑2.16

		Protons	Neutrons	Electrons
a.	$^{34}_{16}S$	16	18	16
b.	$^{91}_{40}Zr$	40	51	40
c.	$^{131}_{54}Xe$	54	77	54

2.17

a.	cadmium-110	$^{110}_{48}Cd$
b.	cobalt-60	$^{60}_{27}Co$
c.	uranium-235	$^{235}_{92}U$

2.18

a.	silicon-28	$^{28}_{14}Si$
b.	argon-40	$^{40}_{18}Ar$
c.	strontium-88	$^{88}_{38}Sr$

2.19

		Mass Number	Atomic Number	Symbol
a.	5 protons and 6 neutrons	11	5	$^{11}_{5}B$
b.	10 protons and 10 neutrons	20	10	$^{20}_{10}Ne$
c.	18 protons and 23 neutrons	41	18	$^{41}_{18}Ar$
d.	50 protons and 76 neutrons	126	50	$^{126}_{50}Sn$

2.20

		Mass Number	Atomic Number	Symbol
a.	4 protons and 5 neutrons	9	4	${}^{9}_{4}Be$
b.	9 protons and 10 neutrons	19	9	${}^{19}_{9}F$
c.	20 protons and 23 neutrons	43	20	${}^{43}_{20}Ca$
d.	47 protons and 60 neutrons	107	47	${}^{107}_{47}Ag$

2.21 a. contains 20 electrons and 20 neutrons ${}^{40}_{20}Ca$

b. contains 1 electron and 2 neutrons ${}^{3}_{1}H$

c. a magnesium atom that contains 14 neutrons ${}^{26}_{12}Mg$

☑2.22 a. contains 17 electrons and 20 neutrons ${}^{37}_{17}Cl$

b. a copper atom with a mass number of 65 ${}^{65}_{29}Cu$

c. a zinc atom that contains 36 neutrons ${}^{66}_{30}Zn$

RELATIVE MASSES OF ATOMS AND MOLECULES (SECTION 2.4)

2.23 Two element pairs whose average atoms have masses that are within 0.3 u of each other are argon (Ar 39.95 u) and calcium (40.08 u) as well as cobalt (Co 58.93u) and nickel (Ni 58.69u).

2.24 $$12 \text{ u}\left(\frac{1 \text{ atom He}}{4 \text{ u He}}\right) = 3 \text{ atoms He}$$

2.25 $$28 \text{ u}\left(\frac{1 \text{ atom Li}}{7 \text{ u Li}}\right) = 4 \text{ atoms Li}$$

2.26 $77.1\% \times 52.00 \text{ u} = 0.771 \times 52.00\text{u} = 40.1 \text{ u}$; Ca; calcium

2.27 In the first 36 elements, the elements with atoms whose average mass is within 0.2 u of being twice the atomic number of the element are:

Atom	Atomic Number	Relative Mass	Ratio
helium (He)	2	4.003	2.002
carbon (C)	6	12.01	2.002
nitrogen (N)	7	14.01	2.001
oxygen (O)	8	16.00	2.000
neon (Ne)	10	20.18	2.018
silicon (Si)	14	28.09	2.006
sulfur (S)	16	32.07	2.004
calcium (Ca)	20	40.08	2.004

2.28 $\frac{1}{2} \times 28.09 \text{ u} = 14.05 \text{ u}$; N; nitrogen

2.29 a. fluorine (F_2) $(2\times 19.00\ u) = 38.00\ u$

b. carbon disulfide (CS_2) $(1\times 12.01\ u)+(2\times 32.07\ u) = 76.15\ u$

c. sulfurous acid (H_2SO_3) $(2\times 1.008\ u)+(1\times 32.07\ u)+(3\times 16.00\ u) = 82.09\ u$

d. ethyl alcohol (C_2H_6O) $(2\times 12.01\ u)+(6\times 1.008\ u)+(1\times 16.00\ u) = 46.07\ u$

e. ethane (C_2H_6) $(2\times 12.01\ u)+(6\times 1.008\ u) = 30.07\ u$

2.30 a. nitrogen dioxide (NO_2) (1x14.01 u) + (2x16.00 u) = 46.01 u

b. ammonia (NH_3) (1x14.01 u) + (3x1.008 u) = 17.03 u

c. glucose ($C_6H_{12}O_6$) (6x12.01 u) + (12x1.008 u) + (6x16.00 u) = 180.16u

d. ozone (O_3) 3x16.00 u = 48.00 u

e. ethylene glycol ($C_2H_6O_2$) (2x12.01 u) + (6x1.008u) = 62.07 u

2.31 The gas is most likely to be N_2O based on the following calculations:

$$NO: (1\times 14.01\ u)+(1\times 16.00\ u) = 30.01\ u$$

$$N_2O: (2\times 14.01\ u)+(1\times 16.00\ u) = 44.02\ u$$

$$NO_2: (1\times 14.01\ u)+(2\times 16.00\ u) = 46.01\ u$$

The experimental value for the molecular weight of an oxide of nitrogen was 43.98 u, which is closest to the theoretical value of 44.02 u, which was calculated for N_2O.

☑2.32 The gas is most likely to be ethylene based on the following calculations:

$$\text{acetylene}: (2\times 12.01\ u)+(2\times 1.008\ u) = 26.04\ u$$

$$\text{ethylene}: (2\times 12.01\ u)+(4\times 1.008\ u) = 28.05\ u$$

$$\text{ethane}: (2\times 12.01\ u)+(6\times 1.008\ u) = 30.07\ u$$

The experimental value for the molecular weight of a flammable gas known to contain only carbon and hydrogen is 28.05 u, which is identical to the theoretical value of 28.05 u, which was calculated for ethylene.

2.33 The x in the formula for glycine stands for 5, the number of hydrogen atoms in the chemical formula.

$$(2\times 12.01\ u)+(x\times 1.008\ u)+(1\times 14.01\ u)+(2\times 16.00\ u) = 75.07\ u$$

$$x\times 1.008\ u + 70.03\ u = 75.07\ u$$

$$x\times 1.008\ u = 5.04\ u$$

$$x = 5$$

2.34 The y in the formula for serine stands for 3, the number of carbon atoms in the chemical formula.

$$(y\times 12.01\ u)+(7\times 1.008\ u)+(1\times 14.01\ u)+(3\times 16.00\ u) = 105.10\ u$$

$$y\times 12.01\ u + 69.07\ u = 105.10\ u$$

$$y\times 12.01\ u = 36.03\ u$$

$$y = 3$$

ISOTOPES AND ATOMIC WEIGHTS (SECTION 2.5)

2.35 a. The number of neutrons in the nucleus $22.9898 - 11 = 11.9898 \approx 12$ neutrons

b. The mass (in u) of the nucleus (to three significant figures) 23.0 u

2.36 a. The number of neutrons in the nucleus $26.982 - 13 = 13.982 \approx 14$ neutrons

b. The mass (in u) of the nucleus (to three significant figures) 27.0 u

2.37 $7.42\% \times 6.0151\text{ u} + 92.58\% \times 7.0160\text{ u} =$

$0.0742 \times 6.0151\text{ u} + 0.9258 \times 7.0160\text{ u} = 6.94173322\text{ u}; 6.942\text{ u with SF}$

or

$$\frac{(7.42 \times 6.0151\text{ u}) + (92.58 \times 7.0160\text{ u})}{100} = 6.94173322\text{ u; } 6.942\text{ u with SF}$$

The atomic weight listed for lithium in the periodic table is 6.941 u. The two values are the very close.

☑2.38 $19.78\% \times 10.0129\text{ u} + 80.22\% \times 11.0093\text{ u} =$

$0.1978 \times 10.0129\text{ u} + 0.8022 \times 11.0093\text{ u} = 10.81221208\text{ u}; 10.812\text{ u with SF}$

or

$$\frac{(19.78 \times 10.0129\text{ u}) + (80.22 \times 11.0093\text{ u})}{100} = 10.81221208\text{ u; } 10.812\text{ u with SF}$$

The atomic weight listed for boron in the periodic table is 10.81 u. The two values are close to one another.

2.39 $92.21\% \times 27.9769\text{ u} + 4.70\% \times 28.9765\text{ u} + 3.09\% \times 29.9738\text{ u} =$

$0.9221 \times 27.9769\text{ u} + 0.0470 \times 28.9765\text{ u} + 0.0309 \times 29.9738\text{ u} = 28.08558541\text{ u; } 28.09\text{ u with SF}$

or

$$\frac{(92.21 \times 27.9769\text{ u}) + (4.70 \times 28.9765\text{ u}) + (3.09 \times 29.9738\text{ u})}{100} = 28.08558541\text{ u; } 28.09\text{ u with SF}$$

The atomic weight listed for silicon in the periodic table is 28.09 u. The two values are the same.

2.40 $69.09\% \times 62.9298\text{ u} + 30.91\% \times 64.9278\text{ u} =$

$0.6909 \times 62.9298\text{ u} + 0.3091 \times 64.9278\text{ u} = 63.5473818\text{ u; } 63.55\text{ u with SF}$

or

$$\frac{(69.09 \times 62.9298\text{ u}) + (30.91 \times 64.9278\text{ u})}{100} = 63.5473818\text{ u; } 63.55\text{ u with SF}$$

The atomic weight listed for copper in the periodic table is 63.55 u. The two values are the same.

AVOGADRO'S NUMBER: THE MOLE (SECTION 2.6)

2.41

$$3.10\ \cancel{g\ P}\left(\frac{6.02\times10^{23}\ \text{atoms P}}{31.0\ \cancel{g\ P}}\right)=6.02\times10^{22}\ \text{atoms P}$$

$$6.02\times10^{22}\ \cancel{\text{atoms S}}\left(\frac{32.1\ \text{g S}}{6.02\times10^{23}\ \cancel{\text{atoms S}}}\right)=3.21\ \text{g S}$$

2.42

$$1.60\ \cancel{g\ O}\left(\frac{6.02\times10^{23}\ \text{atoms O}}{16.00\ \cancel{g\ O}}\right)=6.02\times10^{22}\ \text{atoms O}$$

$$6.02\times10^{22}\ \cancel{\text{atoms F}}\left(\frac{19.0\ \text{g F}}{6.02\times10^{23}\ \cancel{\text{atoms F}}}\right)=1.90\ \text{g F}$$

2.43 a. beryllium

$$1\ \text{mol Be atoms}=6.02\times10^{23}\ \text{Be atoms}$$
$$6.02\times10^{23}\ \text{Be atoms}=9.01\ \text{g Be}$$
$$1\ \text{mol Be atoms}=9.01\ \text{g Be}$$

b. lead

$$1\ \text{mol Pb atoms}=6.02\times10^{23}\ \text{Pb atoms}$$
$$6.02\times10^{23}\ \text{Pb atoms}=207\ \text{g Pb}$$
$$1\ \text{mol Pb atoms}=207\ \text{g Pb}$$

c. sodium

$$1\ \text{mol Na atoms}=6.02\times10^{23}\ \text{Na atoms}$$
$$6.02\times10^{23}\ \text{Na atoms}=23.0\ \text{g Na}$$
$$1\ \text{mol Na atoms}=23.0\ \text{g Na}$$

2.44 ☑a. phosphorus

$$1\ \text{mol P atoms}=6.02\times10^{23}\ \text{P atoms}$$
$$6.02\times10^{23}\ \text{P atoms}=31.0\ \text{g P}$$
$$1\ \text{mol P atoms}=31.0\ \text{g P}$$

☑b. aluminum

$$1\ \text{mol Al atoms}=6.02\times10^{23}\ \text{Al atoms}$$
$$6.02\times10^{23}\ \text{Al atoms}=27.0\ \text{g Al}$$
$$1\ \text{mol Al atoms}=27.0\ \text{g Al}$$

c. krypton

$$1\ \text{mol Kr atoms}=6.02\times10^{23}\ \text{Kr atoms}$$
$$6.02\times10^{23}\ \text{Kr atoms}=83.8\ \text{g Kr}$$
$$1\ \text{mol Kr atoms}=83.8\ \text{g Kr}$$

2.45 a. The number of moles of beryllium atoms in a 10.0-g sample of beryllium

$$1\ \text{mol Be atoms}=9.01\ \text{g Be};\ \frac{1\ \text{mol Be atoms}}{9.01\ \text{g Be}}$$

$$10.0\ \cancel{g\ Be}\left(\frac{1\ \text{mol Be atoms}}{9.01\ \cancel{g\ Be}}\right)=1.11\ \text{mol Be atoms}$$

b. The number of lead atoms in a 2.0-mol sample of lead

$$1\ \text{mol Pb atoms}=6.02\times10^{23}\ \text{Pb atoms};\ \frac{6.02\times10^{23}\ \text{Pb atoms}}{1\ \text{mol Pb atoms}}$$

$$2.00\ \cancel{\text{mol Pb}}\left(\frac{6.02\times10^{23}\ \text{Pb atoms}}{1\ \cancel{\text{mol Pb atoms}}}\right)=1.20\times10^{24}\ \text{Pb atoms}$$

c. The number of sodium atoms in a 50-g sample of sodium

6.02×10^{23} Na atoms = 23.0 g Na; $\dfrac{6.02\times10^{23}\text{ Na atoms}}{23.0\text{ g Na}}$

$$50.0\ \text{g Na}\left(\frac{6.02\times10^{23}\ \text{Na atoms}}{23.0\ \text{g Na}}\right)=1.31\times10^{24}\ \text{Na atoms}$$

2.46 ☑a. The mass in grams of one phosphorus atom

6.02×10^{23} P atoms = 31.0 g P; $\dfrac{31.0\text{ g P}}{6.02\times10^{23}\text{ P atoms}}$

$$1\ \text{atom P}\left(\frac{31.0\ \text{g P}}{6.02\times10^{23}\ \text{P atoms}}\right)=5.15\times10^{-23}\ \text{g P}$$

☑b. The number of grams of aluminum in 1.65 mol of aluminum

1 mol Al atoms = 27.0 g Al; $\dfrac{27.0\text{ g Al}}{1\text{ mol Al atoms}}$

$$1.65\ \text{mol Al}\left(\frac{27.0\ \text{g Al}}{1\ \text{mol Al}}\right)=44.6\ \text{g Al}$$

c. The total mass in grams of one-fourth Avogadro's number of krypton atoms

1 mol Kr atoms = 83.8 g Kr; $\dfrac{83.8\text{ g Kr}}{1\text{ mol Kr atoms}}$

$$\frac{1}{4}\ \text{mol Kr}\left(\frac{83.8\ \text{g Kr}}{1\ \text{mol Kr}}\right)=20.95\ \text{g Kr}$$

(Note: One-fourth is assumed to be an exact number.)

THE MOLE AND CHEMICAL FORMULAS (SECTION 2.7)

2.47 $(1\times31.0\ \text{u})+(3\times1.01\ \text{u})=34.0\ \text{u};\ 1\ \text{mole } PH_3=34.0\ \text{g } PH_3$

$(1\times32.1\ \text{u})+(2\times16.0\ \text{u})=64.1\ \text{u};\ 1\ \text{mole } SO_2=64.1\ \text{g } SO_2$

$$6.41\ \text{g } SO_2\left(\frac{6.02\times10^{23}\ \text{molecules } SO_2}{64.1\ \text{g } SO_2}\right)=6.02\times10^{22}\ \text{molecules } SO_2$$

$$6.02\times10^{22}\ \text{molecules } PH_3\left(\frac{34.0\ \text{g } PH_3}{6.02\times10^{23}\ \text{molecules } PH_3}\right)=3.40\ \text{g } PH_3$$

2.48 $(1\times10.8\ \text{u})+(3\times19.0\ \text{u})=67.8\ \text{u};\ 1\ \text{mole } BF_3=67.8\ \text{g } BF_3$

$(2\times1.01\ \text{u})+(1\times32.1\ \text{u})=34.1\ \text{u};\ 1\ \text{mole } H_2S=34.1\ \text{g } H_2S$

$$0.34\ \text{g } H_2S\left(\frac{6.02\times10^{23}\ \text{molecules } H_2S}{34.1\ \text{g } H_2S}\right)=6.0\times10^{21}\ \text{molecules } H_2S$$

$$6.0\times10^{21}\ \text{molecules } BF_3\left(\frac{67.8\ \text{g } BF_3}{6.02\times10^{23}\ \text{molecules } BF_3}\right)=0.68\ \text{g } BF_3$$

2.49 a. carbon dioxide (CO_2)

1. 2 CO2 molecules contain 2 C atoms and 4 O atoms.
2. 10 CO_2 molecules contain 10 C atoms and 20 O atoms.
3. 100 CO_2 molecules contain 100 C atoms and 200 O atoms.
4. 6.02×10^{23} CO_2 molecules contain 6.02×10^{23} C atoms and $12.04\text{x}10^{23}$ O atoms.
5. 1 mole of CO_2 contains 1 mole of C atoms and 2 moles of O atoms.
6. 44.01 g of CO_2 contains 12.01 g of C atoms and 32.00 g of O.

b. ethane (C_2H_6)

1. 2 C_2H_6 molecules contain 4 C atoms and 12 H atoms.
2. 10 C_2H_6 molecules contain 20 C atoms and 60 H atoms.
3. 100 C_2H_6 molecules contain 200 C atoms and 600 H atoms.
4. 6.02×10^{23} C_2H_6 molecules contain 12.04×10^{23} C atoms and 36.12×10^{23} H atoms.
5. 1 mol of C_2H_6 molecules contains 2 mole of C atoms and 6 moles of H atoms.
6. 30.08 g of C_2H_6 contains 24.02 g of C and 6.06 g of H.

c. glucose ($C_6H_{12}O_6$)

1. 2 $C_6H_{12}O_6$ molecules contain 12 C atoms, 24 H atoms, and 12 O atoms.
2. 10 $C_6H_{12}O_6$ molecules contain 60 C atoms, 120 H atoms, and 60 O atoms.
3. 100 $C_6H_{12}O_6$ molecules contain 600 C atoms, 1200 H atoms, and 600 O atoms.
4. 6.02×10^{23} $C_6H_{12}O_6$ molecules contain 36.12×10^{23} C atoms, 72.24×10^{23} H atoms, and 36.12×10^{23} O atoms.
5. 1 mole of $C_6H_{12}O_6$ contains 6 mole of C atoms, 12 moles of H atoms, and 6 moles O atoms.
6. 180.18 g of $C_6H_{12}O_6$ contains 72.06 g of C, 12.12 g of H, and 96.00 g of O.

2.50 a. ethyl ether ($C_4H_{10}O$)

1. 2 $C_4H_{10}O$ molecules contain 8 C atoms, 20 H atoms, and 2 O atoms.
2. 10 $C_4H_{10}O$ molecules contain 40 C atoms, 100 H atoms, and 10 O atoms.
3. 100 $C_4H_{10}O$ molecules contain 400 C atoms, 1000 H atoms, and 100 O atoms.
4. $6.02 \text{ x } 10^{23}$ $C_4H_{10}O$ molecules contain $24.08 \text{ x } 10^{23}$ C atoms, $60.2\text{x}10^{23}$ H atoms, and $6.02 \text{ x } 10^{23}$ O atoms.
5. 1 mol of $C_4H^{10}O$ molecules contain 4 moles of C atoms, 10 moles of H atoms, and 1 mole O atoms.
6. 74.1 g of ethyl ether contains 48.0 g of C, 10.1 g of H, and 16.0 g of O.

☑b. fluoroacetic acid ($C_2H_3O_2F$)

1. 2 $C_2H_3O_2F$ molecules contain 4 C atoms, 6 H atoms, 4 O atoms, and 2 F atoms.
2. 10 $C_2H_3O_2F$ molecules contain 20 C atoms, 30 H atoms, 20 O atoms, and 10 F atoms.
3. 100 $C_2H_3O_2F$ molecules contain 200 C atoms, 300 H atoms, 200 O atoms, and 100 F atoms.

4. 6.02×10^{23} $C_2H_3O_2F$ molecules contain 12.04×10^{23} C atoms, 18.06×10^{23} H atoms, 12.04×10^{23} O atoms, and 6.02×10^{23} F atoms.
5. 1 mol of $C_2H_3O_2F$ molecules contain 2 moles of C atoms, 3 moles of H atoms, 2 moles of O atoms, and 1 mole of F atoms.
6. 78.0 g of fluoroacetic acid contains 24.0 g of C, 3.03 g of H, 32.0 g of O, and 19.0 g of F.

c. Aniline (C_6H_7N)

1. 2 C_6H_7N molecules contain 12 C atoms, 14 H atoms, and 2 N atoms.
2. 10 C_6H_7N molecules contain 60 C atoms, 70 H atoms, and 10 N atoms.
3. 100 C_6H_7N molecules contain 600 C atoms, 700 H atoms, and 100 N atoms.
4. 6.02×10^{23} C_6H_7N molecules contain 36.12×10^{23} C atoms, 42.14×10^{23} H atoms, and 6.02×10^{23} N atoms.
5. 1 mol of C_6H_7N molecules contain 6 moles of C atoms, 7 moles of H atoms, and 1 mole N atoms.
6. 93.1 g of aniline contains 72.0 g of C, 7.07 g of H, and 14.0 g of N.

2.51 a. **Statement 5.** 1 mol of CO_2 molecules contains 1 mole of C atoms and 2 moles of O atoms.

$$\text{Factor: } \left(\frac{2 \text{ moles O atoms}}{1 \text{ mole } CO_2}\right)$$

$$1 \cancel{\text{mol } CO_2}\left(\frac{2 \text{ moles O atoms}}{1 \cancel{\text{mole } CO_2}}\right) = 2 \text{ moles O atoms}$$

b. **Statement 6.** 30.0 g of C_2H_6 contains 24.02 g of C and 6.06 g of H.

$$\text{Factor: } \left(\frac{24.02 \text{ g C}}{1 \text{ mole } C_2H_6}\right)$$

$$1.00 \cancel{\text{mole } C_2H_6}\left(\frac{24.02 \text{ g C}}{1 \cancel{\text{mole } C_2H_6}}\right) = 24.02 \text{ g C}$$

c. **Statement 6.** 180.18 g of $C_6H_{12}O_6$ contains 72.06 g of C, 12.12 g of H, and 96.00 g of O.

$$\text{Factor: } \left(\frac{96.00 \text{ g O}}{180.18 \text{ g } C_6H_{12}O_6}\right)$$

$$\left(\frac{96.00 \text{ g O}}{180.18 \text{ g } C_6H_{12}O_6}\right) \times 100 = 53.28\% \text{ O in } C_6H_{12}O_6$$

2.52 a. **Statement 5.** 1 mol of $C_4H_{10}O$ molecules contains 4 moles of C atom, 10 moles of H atoms, and 1 mole of O atoms.

$$\text{Factor: } \left(\frac{10 \text{ moles H atoms}}{1 \text{ mole } C_4H_{10}O}\right)$$

$$0.50 \cancel{\text{mol } C_4H_{10}O}\left(\frac{10 \text{ moles H atoms}}{1 \cancel{\text{mole } C_4H_{10}O}}\right) = 5.0 \text{ moles H atoms}$$

☑b. **Statement 4.** 6.02×10^{23} $C_2H_3O_2F$ molecules contain 12.04×10^{23} C atoms, 18.06×10^{23} H atoms, 12.04×10^{23} O atoms, and 6.02×10^{23} F atoms.

$$\text{Factor}: \left(\frac{12.04\times10^{23}\ \text{C atoms}}{1\ \text{mole}\ C_2H_3O_2F}\right)$$

$$0.25\ \cancel{\text{mole}\ C_2H_3O_2F}\left(\frac{12.04\times10^{23}\ \text{C atoms}}{1\ \cancel{\text{mole}\ C_2H_3O_2F}}\right)=3.0\times10^{23}\ \text{C atoms}$$

c. **Statement 6.** 93.1 g of aniline contains 72.0 g of C, 7.07 g of H, and 14.0 g of N.

$$\text{Factor}: \left(\frac{7.07\ \text{g H}}{1\ \text{mole}\ C_6H_7N}\right)$$

$$2.00\ \cancel{\text{mol}\ C_6H_7N}\left(\frac{7.07\ \text{g H}}{1\ \cancel{\text{mole}\ C_6H_7N}}\right)=1.41\ \text{g H}$$

2.53

$$3.0\ \cancel{\text{mole}\ NO_2}\left(\frac{1\ \cancel{\text{mole N atoms}}}{1\ \cancel{\text{mole}\ NO_2}}\right)\left(\frac{1\ \text{mole}\ N_2O_5}{2\ \cancel{\text{moles N atoms}}}\right)=1.5\ \text{moles}\ N_2O_5$$

Note: The 3 mol assumed to be an exact number.

2.54

$$0.75\ \cancel{\text{mole}\ H_2O}\left(\frac{1\ \cancel{\text{mole O atoms}}}{1\ \cancel{\text{mole}\ H_2O}}\right)\left(\frac{6.02\times10^{23}\ \text{O atoms}}{1\ \cancel{\text{mole O atoms}}}\right)=4.515\times10^{23}\ \text{O atoms}$$

$$4.515\times10^{23}\ \cancel{\text{O atoms}}\left(\frac{1\ \text{mole}\ \cancel{\text{O atoms}}}{6.02\times10^{23}\ \cancel{\text{O atoms}}}\right)\left(\frac{1\ \cancel{\text{mole}\ C_2H_6O}}{1\ \text{mole}\ \cancel{\text{O atoms}}}\right)\left(\frac{46.1\ \text{g}\ C_2H_6O}{1\ \cancel{\text{mole}\ C_2H_6O}}\right)$$

$$=34.575\ \text{g}\ C_2H_6O\approx35\ \text{g with SF}$$

2.55

$$\frac{12.01\ \text{g of C}}{28.01\ \text{g of CO}}\times100=42.88\%\ \text{C in CO}\qquad\frac{12.01\ \text{g of C}}{44.01\ \text{g of}\ CO_2}\times100=27.29\%\ \text{C in}\ CO_2$$

2.56

$$\frac{4.04\ \text{g H}}{16.0\ \text{g}\ CH_4}\times100=25.3\%\ \text{H in}\ CH_4\qquad\frac{6.06\ \text{g H}}{30.1\ \text{g}\ C_2H_6}\times100=20.1\%\ \text{H in}\ C_2H_6$$

2.57 **Statement 4.** 6.02×10^{23} $C_6H_5NO_3$ molecules contain 36.12×10^{23} C atoms, 30.1×10^{23} H atoms, 6.02×10^{23} N atoms, and 18.06×10^{23} O atoms.

Statement 5. 1 mol $C_6H_5NO_3$ molecules contain 6 moles of C atoms, 5 moles of H atoms, 1 mole of N atoms, and 3 moles of O atoms.

Statement 6. 139 g of nitrophenol contains 72.0 g of C, 5.05 g of H, 14.0 g of N, and 48.0 g of O.

a. **Statement 6.** 139 g of nitrophenol contains 72.0 g of C, 5.05 g of H, 14.0 g of N, and 48.0 g of O.

$$\text{Factor}: \left(\frac{14.0\ \text{g N}}{139\ \text{g}\ C_6H_5NO_3}\right)$$

$$70.0\ \cancel{\text{g}\ C_6H_5NO_3}\left(\frac{14.0\ \text{g N}}{139\ \cancel{\text{g}\ C_6H_5NO_3}}\right)=7.05\ \text{g N}$$

b. **Statement 5.** 1 mol $C_6H_5NO_3$ molecules contain 6 moles of C atoms, 5 moles of H atoms, 1 mole of N atoms, and 3 moles of O atoms.

$$\text{Factor}: \left(\frac{3 \text{ moles of O atoms}}{1 \text{ mole } C_6H_5NO_3}\right)$$

$$1.50 \ \cancel{\text{moles } C_6H_5NO_3}\left(\frac{3 \text{ moles of O atoms}}{1 \ \cancel{\text{mole } C_6H_5NO_3}}\right) = 4.50 \text{ moles of O atoms}$$

c. **Statement 4.** 6.02×10^{23} $C_6H_5NO_3$ molecules contain 36.12×10^{23} C atoms, 30.1×10^{23} H atoms, 6.02×10^{23} N atoms, and 18.06×10^{23} O atoms.

$$\text{Factor}: \left(\frac{36.12\times10^{23} \text{ C atoms}}{6.02\times10^{23} \ C_6H_5NO_3 \text{ molecules}}\right)$$

$$9.00\times10^{22} \ \cancel{\text{molecules } C_6H_5NO_3}\left(\frac{36.12\times10^{23} \text{ C atoms}}{6.02\times10^{23} \ \cancel{C_6H_5NO_3 \text{ molecules}}}\right) = 5.4\times10^{23} \text{ C atoms}$$

2.58 a. **Statement 6.** 180 g of fructose contains 72.0 g of C, 12.1 g of H, and 96.0 g of O.

$$\text{Factor:}\left(\frac{96.0 \text{ g O}}{180 \text{ g } C_6H_{12}O_6}\right)$$

$$43.5 \ \cancel{\text{g } C_6H_{12}O_6}\left(\frac{96.0 \text{ g O}}{180 \ \cancel{\text{g } C_6H_{12}O_6}}\right) = 23.2 \text{ g O}$$

b. **Statement 5.** 1 mol $C_6H_{12}O_6$ molecules contain 6 moles of C atoms, 12 moles of H atoms, 6 moles of O atoms.

$$\text{Factor:}\left(\frac{12 \text{ moles of H atoms}}{1 \text{ mole } C_6H_{12}O_6}\right)$$

$$1.50 \ \cancel{\text{moles } C_6H_{12}O_6}\left(\frac{12 \text{ moles of H atoms}}{1 \ \cancel{\text{mole } C_6H_{12}O_6}}\right) = 18.0 \text{ moles of H atoms}$$

c. **Statement 4**. 6.02 x 10^{23} $C_6H_{12}O_6$ molecules contain 36.12 x 10^{23} C atoms, 72.24x10^{23} H atoms, and 36.12 x 10^{23} O atoms.

$$\text{Factor:}\left(\frac{36.12\times10^{23} \text{ C atoms}}{6.02\times10^{23} \ C_6H_{12}O_6 \text{ molecules}}\right)$$

$$7.50\times10^{23} \ \cancel{\text{molecules of } C_6H_{12}O_6}\left(\frac{36.12\times10^{23} \text{ C atoms}}{6.02\times10^{23} \ \cancel{C_6H_{12}O_6 \text{ molecules}}}\right) = 4.50\times10^{23} \text{ C atoms}$$

2.59 Urea (CH_4N_2O) contains the higher mass percentage of nitrogen as shown in the calculation below:

$$\frac{28.0 \text{ g N}}{60.0 \text{ g } CH_4N_2O}\times100 = 46.7\% \text{ N in } CH_4N_2O \qquad \frac{28.0 \text{ g N}}{132 \text{ g } N_2H_8SO_4}\times100 = 21.2\% \text{ N in } N_2H_8SO_4$$

2.60 Magnetite (Fe_3O_4) contains the higher mass percentage of iron as shown in the calculation below:

$$\frac{167 \text{ g Fe}}{231 \text{ g } Fe_3O_4}\times100 = 72.3\% \text{ Fe in } Fe_3O_4 \qquad \frac{112 \text{ g Fe}}{160 \text{ g } Fe_2O_3}\times100 = 70.0\% \text{ Fe in } Fe_2O_3$$

2.61 Calcite ($CaCO_3$) contains the higher mass percentage of nitrogen as shown in the calculation below:

$$\frac{40.1\text{ g Ca}}{100.\text{ g CaCO}_3}\times 100 = 40.1\%\text{ Ca in CaCO}_3$$

$$\frac{40.1\text{ g Ca}}{184\text{ g CaMgC}_2\text{O}_6}\times 100 = 21.8\%\text{ Ca in CaMgC}_2\text{O}_6$$

ADDITIONAL EXERCISES

2.62 U-238 contains 3 more neutrons in its nucleus than U-235. U-238 and U-235 have the same volume because the extra neutrons in U-238 do not change the size of the electron cloud. U-238 is 3u heavier than U-235 because of the 3 extra neutrons. Density is a ratio of mass to volume; therefore, U-238 is more dense than U-235 because it has a larger mass divided by the same volume.

2.63 $$\frac{1.0\times 10^{9}}{6.02\times 10^{23}}\times 100 = 1.66\times 10^{-13}\%$$

2.64 $$\frac{1.99\times 10^{-23}\text{ g}}{1\ \cancel{\text{C}-12\text{ atom}}}\left(\frac{1\ \cancel{\text{C}-12\text{ atom}}}{12\ \cancel{\text{protons + neutrons}}}\right)\left(\frac{14\ \cancel{\text{protons + neutrons}}}{1\text{ C}-14\text{ atom}}\right) = \frac{2.32\times 10^{-23}\text{ g}}{1\text{ C}-14\text{ atom}}$$

2.65 $$\text{D}_2\text{O}: (2\times 2\text{ u}) + (1\times 16.00\text{ u}) = 20\text{ u}$$

2.66 In Figure 2.2, the electrons are much closer to the nucleus than they would be in a properly scaled drawing. Consequently, the volume of the atom represented in Figure 2.2 is much less than it should be. Density is calculated as a ratio of mass to volume. The mass of this atom has not changed; however, the volume has decreased. Therefore, the atom in Figure 2.2 is much more dense than an atom that is 99.999% empty.

CHEMISTRY FOR THOUGHT

2.67
a. Atoms of different elements contain different numbers of protons.
b. Atoms of different isotopes contain different numbers of neutrons, but the same number of protons.

2.68 Aluminum exists as one isotope; therefore, all atoms have the same number of protons and neutrons as well as the same mass. Nickel exists as several isotopes; therefore, the individual atoms do not have the weighted average atomic mass of 58.69 u.

2.69 $$\frac{2.36\times 10^{3}\text{ g}}{12\text{ oranges}} = 197\frac{\text{g}}{\text{orange}}$$

None of the oranges in the bowl is likely to have the exact mass calculated as an average. Some oranges will weigh more than the average and some will weigh less.

2.70 $$\frac{\text{dry bean mass}}{\text{jelly bean mass}} = \frac{1}{1.60}$$

$$472\ \cancel{\text{g jelly beans}}\left(\frac{1\ \text{g dry beans}}{1.60\ \cancel{\text{g jelly beans}}}\right) = 295\ \text{g dry beans}$$

$$472\ \cancel{\text{g jelly beans}}\left(\frac{1\ \text{jelly bean}}{1.18\ \cancel{\text{g jelly bean}}}\right) = 400\ \text{jelly beans}$$ Each jar contains 400 beans.

2.71 $$1.5\ \cancel{\text{mol } CS_2}\left(\frac{2\ \text{mol S atoms}}{1\ \cancel{\text{mol } CS_2}}\right) = 3.0\ \text{mol S atoms}$$

$$0.25\ \cancel{\text{mol S}}\left(\frac{6.02\times10^{23}\ CS_2\ \text{molecules}}{2\ \cancel{\text{mol S}}}\right) = 7.5\times10^{22}\ CS_2\ \text{molecules}$$

2.72 If the atomic mass unit were redefined as being equal to 1/24th the mass of a carbon-12 atom, then the atomic weight of a carbon-12 atom would be 24 u. Changing the definition for an atomic mass unit does not change the relative mass ratio of carbon to magnesium. Magnesium atoms are approximately 2.024 times as heavy as carbon-12 atoms; therefore, the atomic weight of magnesium would be approximately 48.6 u.

2.73 The ratio of the atomic weight of magnesium divided by the atomic weight of hydrogen would not change, even if the atomic mass unit was redefined.

2.74 The value of Avogadro's number would not change even if the atomic mass unit were redefined. Avogadro's number is the number of particles in one mole and has a constant value of 6.022 x 10^{23}.

ALLIED HEALTH EXAM CONNECTION

2.75 The symbol K on the periodic table stands for (a) potassium.

2.76 (b) Water is a chemical compound. (a) Blood and (d) air are mixtures, while (c) oxygen is an element.

2.77 (c) Compounds are pure substances that are composed of two or more elements in a fixed proportion. Compounds can be broken down chemically to produce their constituent elements or other compounds.

2.78 $^{34}_{17}Cl$ has (a) 17 protons, 17 neutrons (34-17=17), and 17 electrons (electrons = protons in neutral atom).

2.79 If two atoms are isotopes, they will (c) have the same number of protons, but different numbers of neutrons.

2.80 Copper has (b) 29 protons because the atomic number is the number of protons.

2.81 Atoms are electrically neutral. This means that an atom will contain (c) an equal number of protons and electrons.

2.82 The negative charged particle found within the atom is the (b) electron.

2.83 Two atoms, L and M are isotopes; therefore, they would not have (b) atomic weight in common.

2.84 The major portion of an atom's mass consists of (a) neutrons and protons.

2.85 The mass of an atom is almost entirely contributed by its (a) nucleus.

2.86 (d) ${}^{33}_{16}S^{2-}$ has 16 protons, 17 neutrons, and 18 electrons.

2.87 An atom with an atomic number of 58 and an atomic mass of 118 has (c) 60 neutrons.

2.88 The mass number of an atom with 60 protons, 60 electrons, and 75 neutrons is (b) 135.

2.89 Avogadro's number is (c) 6.022×10^{23}.

2.90 (c) 1.0 mol NO_2 has the greatest number of atoms (1.8×10^{24} atoms). 1.0 mol N has 6.0×10^{23} atoms, 1.0 g N has 4.3×10^{22} atoms, and 0.5 mol NH_3 has 1.2×10^{24} atoms.

2.91 A sample of 11 grams of CO_2 contains (c) 3.0 grams of carbon.

$$11\ \cancel{g\ CO_2}\left(\frac{12.0\text{ g C}}{44.0\ \cancel{g\ CO_2}}\right) = 3.0\text{ g C}$$

2.92 The molar mass of calcium oxide, CaO, is (a) 56 g (40 g Ca + 16 g O).

2.93 The mass of 0.200 mol of calcium phosphate is (b) 62.0 g.

$$0.200\ \cancel{mol\ Ca_3(PO_4)_2}\left(\frac{310\text{ g } Ca_3(PO_4)_2}{1\ \cancel{mol\ Ca_3(PO_4)_2}}\right) = 62.0\text{ g } Ca_3(PO_4)_2$$

2.94 (b) 2.0 moles Al are contained in a 54.0 g sample of Al.

$$54.0\ \cancel{g\ Al}\left(\frac{1\text{ mole Al}}{27.0\ \cancel{g\ Al}}\right) = 2.00\text{ mole Al}$$

EXAM QUESTIONS
MULTIPLE CHOICE

1. Why is CaO the symbol for calcium oxide instead of CAO?
   a. They both can be the symbols for calcium oxide.
   b. They are both incorrect as the symbol should be cao.
   c. A capital letter means a new symbol.
   d. They are both incorrect as the symbol should be CaOx.

   Answer: C

2. What is the meaning of the two in ethyl alcohol, C_2H_5OH?
   a. All alcohol molecules contain two carbon atoms.

b. There are two carbon atoms per molecule of ethyl alcohol.
c. Carbon is diatomic.
d. All of these are correct statements.

Answer: B

3. The symbols for elements with accepted names:
   a. consist of a single capital letter.
   b. consist of a capital letter and a small letter.
   c. consist of either a single capital letter or a capital letter and a small letter.
   d. no answer is correct

Answer: C

4. A molecular formula:
   a. is represented using the symbols of the elements in the formula.
   b. is represented using a system of circles that contain different symbols.
   c. cannot be represented conveniently using symbols for the elements.
   d. is represented using words rather than symbols.

Answer: A

5. Which of the following uses the unit of "u"?
   a. atomic weights of atoms
   b. relative masses of atoms
   c. molecular weights of molecules
   d. more than one response is correct

Answer: D

6. What is meant by carbon-12?
   a. The carbon atom has a relative mass of approximately 12 grams.
   b. The carbon atom has a relative mass of approximately 12 pounds.
   c. The carbon atom has a relative mass of approximately 12 amu.
   d. The melting point of carbon is 12˚C.

Answer: C

7. Refer to a periodic table and tell how many helium atoms (He) would be needed to get close to the same mass as an average oxygen atom (O).
   a. six
   b. four
   c. twelve
   d. one-fourth

Answer: B

8. Determine the molecular weight of hydrogen peroxide, H_2O_2 in u.
   a. 17.01
   b. 18.02
   c. 34.02
   d. 33.01

Answer: C

9. Using whole numbers, determine the molecular weight of calcium hydroxide, $Ca(OH)_2$.
   a. 56
   b. 57
   c. 58
   d. 74

Answer: D

10. The average relative mass of an ozone molecule is 48.0 u. An ozone molecule contains only oxygen atoms. What does this molecular weight indicate about the formula of the ozone molecule?
   a. It contains a single oxygen atom.
   b. It contains two oxygen atoms.
   c. It contains three oxygen atoms.
   d. The data tell nothing about the formula of an ozone molecule.

Answer: C

11. Which of the following pairs are about equal in mass?
    a. proton and electron
    b. electron and neutron
    c. proton and neutron
    d. nucleus and surrounding electron

Answer: C

12. Which of the following particles is the smallest?
    a. proton
    b. electron
    c. neutron
    d. they are all the same size

Answer: B

13. How many electrons are in a neutral atom of carbon-13, ^{13}C?
    a. 6
    b. 18
    c. 12
    d. no way to tell

Answer: A

14. Which of the following carries a negative charge?
    a. a proton
    b. a neutron
    c. an electron
    d. both proton and neutron

Answer: C

15. Which of the following is located in the nucleus of an atom?
    a. protons
    b. neutrons
    c. electrons
    d. protons and neutrons

Answer: D

16. Atoms are neutral. How can they have no charge?
    a. equal numbers of protons and neutrons
    b. equal numbers of protons and electrons
    c. equal numbers of neutrons and electrons
    d. any charge has been drained out of the atom

Answer: B

17. Isotopes differ from each other in what way?
    a. They have different numbers of protons in the nucleus.
    b. They have different numbers of neutrons in the nucleus.
    c. They have different numbers of electrons outside the nucleus.
    d. More than one response is correct

Answer: B

18. In what way is U-238 different from U-235?
    a. three more electrons
    b. three more protons
    c. three more neutrons
    d. there is no difference

Answer: C

19. How many protons are found in the nucleus of a boron-11 (B) atom?
    a. 11
    b. 6
    c. 5
    d. 4

Answer: C

20. How many neutrons are found in the nucleus of a boron-11 (B) atom?
    a. 11
    b. 6
    c. 5
    d. 4

Answer: B

21. What is the mass number of a carbon-13 (C) atom?
    a. 13 b. 12 c. 6 d. 7

Answer: A

22. Naturally occurring neon (Ne) has the following isotopic composition (the mass of each isotope is given in parenthesis). Calculate the atomic weight of neon in u from these data.
    neon-20, 90.92% (19.99 u); neon-21, 0.257% (20.99 u); neon-22, 8.82% (21.99 u)
    a. 28.97 b. 37.62 c. 2017 d. 20.17

Answer: D

23. Naturally occurring lithium (Li) consists of only two isotopes, Li-6 (6.02 u) and Li-7 (7.02 u), where the isotopic masses are given in parentheses. Use the periodic table and determine which isotope is present in the larger percentage in the natural element.
    a. Li-6
    b. Li-7
    c. each is present at 50%
    d. cannot be determined from the information available

Answer: B

24. What mass of arsenic (As) in grams contains the same number of atoms as 39.95 g of argon (Ar)?
    a. 33.0 b. 74.92 c. 4.16 d. 149.84

Answer: B

25. Which is greater: the number of Cr atoms in a 26.0 g sample of chromium or the number of Al atoms in a 26.98 g sample of aluminum?
    a. The number of Cr atoms is greater than the number of Al atoms.
    b. The number of Al atoms is greater than the number of Al atoms.
    c. The number of Cr atoms and Al atoms are the same.
    d. The number of Cr atoms and Al atoms cannot be determined from the provided data.

Answer: B

26. The mass of mercury (Hg), a liquid at room temperature, is 200.6 g/mol. A 200.6 gram sample of mercury is heated until it boils. What is the mass of one mole of mercury vapor (gas)?
    a. less than 200.6 or it would not be a gas
    b. the same as Avogadro's number
    c. the same as when it is a liquid
    d. none of the answers is correct

Answer: C

27. The formula for dinitrogen monoxide is N_2O. If a sample of the oxide was found to contain 0.0800 g of oxygen, how many grams of nitrogen would it contain?
    a. 0.140 b. 0.280 c. 0.560 d. 0.0700

Answer: A

28. Avogadro's number of iron (Fe) atoms would weigh
    a. 55.85 g b. 27.95 g c. 6.02×10^{23} g d. 6.02×10^{-23} g

Answer: A

29. How many atoms are contained in a sample of krypton, Kr, that weighs 8.38 g?
    a. Avogadro's number
    b. one-tenth Avogadro's number
    c. one
    d. one-tenth

    Answer: B

30. Which of the following has the largest mass?
    a. 5.0 mol H_2O
    b. 3.5 mol NH_3
    c. 8.0 mol C
    d. 6.0 mol C_2H_2

    Answer: D

31. How many silicon atoms (Si) are contained in a 12.5 g sample of silicon?
    a. 2.68×10^{23}
    b. 5.83×10^{-22}
    c. 1.35×10^{24}
    d. 1.71×10^{21}

    Answer: A

32. What is the number of hydrogen atoms in a 18.016 gram sample of water?
    a. 2.000
    b. 6.022×10^{23}
    c. 18.02
    d. 1.204×10^{24}

    Answer: D

33. How many moles of oxygen atoms are in one mole of CO_2?
    a. 1
    b. 2
    c. 6.02×10^{23}
    d. 12.04×10^{23}

    Answer: B

34. How many hydrogen atoms are in 1.00 mole of NH_3?
    a. 3.00
    b. 6.02×10^{23}
    c. 12.0×10^{23}
    d. 18.1×10^{23}

    Answer: D

35. How many moles of hydrogen molecules (H_2) contain the same number of hydrogen atoms as two moles of hydrogen peroxide (H_2O_2)?
    a. 1
    b. 2
    c. 3
    d. 4

    Answer: B

36. Calculate the weight percentage of hydrogen in water, rounded to 3 significant figures.
    a. 33.3
    b. 66.7
    c. 2.00
    d. 11.2

    Answer: D

37. What is the weight percentage of nitrogen in urea, CN_2H_4O, rounded to 3 significant figures?
    a. 46.7
    b. 30.4
    c. 32.6
    d. 16.3

    Answer: A

38. How many carbon atoms are contained in 5.50 g of ethane, C_2H_6?
    a. 2.75×10^{-22}
    b. 3.29×10^{24}
    c. 1.10×10^{23}
    d. 2.20×10^{23}

    Answer: D

39. Which element is approximately 65 percent of sulfuric acid (H_2SO_4) by weight?
    a. hydrogen
    b. sulfur
    c. oxygen
    d. any of these

    Answer: C

40. How many moles of N_2O contain the same number of nitrogen atoms as 4.60 g of NO_2?
  a. 0.500 b. 0.0500 c. 0.100 d. 0.200

Answer: B

41. How many grams of iron (Fe) are contained in 15.8 g of $Fe(OH)_3$?
  a. 12.1 b. 8.26 c. 11.8 d. 5.21

Answer: B

42. What is the symbol for bromine?
  a. B b. Br c. Be d. none of these

Answer: B

43. What is the weight percent of sulfur in K_2SO_4, rounded to 3 significant figures?
  a. 14.2% b. 18.4% c. 54.4% d. 22.4%

Answer: B

44. What is the number of moles of water in one liter of water if one gram of water takes up one milliliter of space?
  a. 1 b. 18 c. 55.6 d. 1000

Answer: C

45. How many neutrons are in an atom that has a mass number of 75 and contains 35 protons?
  a. 40 b. 35 c. 75 d. no way to know

Answer: A

46. Atoms that have the same atomic number but differ by mass number are called?
  a. protons b. neutrons c. isotopes d. positrons

Answer: C

47. If you have 3.011×10^{23} atoms of carbon, what would you expect their combined mass to be?
  a. 12.01 g b. 6.005 g c. 3.003 g d. 1.000 g

Answer: B

48. What is wrong with the following molecular formula: SOO (sulfur dioxide)
  a. OSO is the correct form
  b. SO should be So
  c. OO should be written as O2
  d. OO should be written as O_2

Answer: D

49. Determine the number of electrons and protons in element 43, technetium, Tc.
  a. 43 protons, 43 electrons
  b. 43 protons, 56 electrons
  c. 56 protons, 43 electrons
  d. 99 protons, 43 electrons

Answer: A

50. Upon which of the following is the system of atomic mass units based?
  a. Assigning C-12 as weighing exactly 12 u and comparing other elements to it.
  b. Measuring the true mass of each subatomic particle.
  c. Comparing the differences in protons and electrons.
  d. Viewing how atoms are affected by electromagnetic fields.

Answer: A

TRUE-FALSE

1. The symbols for all of the elements are derived from the Latin names.

   Answer: F

2. The symbols for all of the elements always begin with a capital letter.

   Answer: T

3. The first letter of the symbol for each of the elements is the first letter of its English name.

   Answer: F

4. The most accurate way to determine atomic mass is with a mass spectrometer.

   Answer: T

5. H_2O_2 contains equal parts by weight of hydrogen and oxygen.

   Answer: F

6. Electrons do not make an important contribution to the mass of an atom.

   Answer: T

7. The charge of the nucleus depends only on the atomic number.

   Answer: T

8. Isotopes of the same element always have the same number of neutrons.

   Answer: F

9. Isotopes of the same element always have the same atomic number.

   Answer: T

10. Isotopes of the same element always have the same atomic mass.

    Answer: F

11. A mole of copper contains the same number of atoms as a mole of zinc.

    Answer: T

12. One mole of average atoms of an element would have the same mass as a mole of one isotope of the same element.

    Answer: F

13. One mole of silver has the same mass as a mole of gold.

    Answer: F

14. One mole of H_2O contains two moles of hydrogen atoms.

    Answer: T

15. One mole of H_2O contains 2.0 grams of hydrogen.

    Answer: T

16. One mole of O_3 weighs 16 grams.

Answer: F

17. The pure substance, water, contains both hydrogen molecules and oxygen molecules.

Answer: F

18. A diet is planned for a trip on a space ship and is lacking in milk, but is rich in turnips and broccoli. Such a diet could provide a sufficient amount of calcium for adults.

Answer: T

19. Calcium supplements can be taken in 1,000 mg increments.

Answer: F

20. Protons and neutrons have approximately the same mass.

Answer: T

EXPERIMENT 2: THE USE OF CHEMICAL BALANCES

Instructor Tips

1. Remind students that they can begin with either of the balances. They don't have to do parts A and B in that order. This will help reduce waiting lines at the balances.

2. Remind students to record their unknown identification numbers on their experiment sheets.

3. Remind students to keep their unknowns for use in both parts A and B of the experiment.

4. Emphasize to students that they should not use any balances until they have been properly instructed.

5. Point out to students that example 2.1 in Part A, and example 2.2 in Part D are examples only, and should not be treated as experimental procedures.

Pre-Lab Review Answers

1. No specific safety alerts are given.

2. Part D, sodium chloride in sink.

3. Centigram: 2.62 g. Electronic (intermediate sens.): 2.621 g. Electronic (high sens.): 2.6211 g.

4. Average mass should be reported as 2.5368 g, using five significant figures to match the five in 10.147 g.

5. According to instructions given in the calculations and report section, the x value would be 4, and the y value (rounded to the nearest 0.1) would be 10.1.

6. In direct weighings, object is placed directly on balance and weighed. When weighing is done by difference, the object is weighed in a container. The container is weighed alone, and the mass of the object is obtained by subtracting the container mass from the mass of container-plus-object.

7. Weighing by difference is used when accurate masses are wanted, because the procedure eliminates errors in the balance such as an incorrect zero setting.

8. Accurate masses are usually recorded as data.

9. An approximate sample mass is determined by placing a container on the balance, and adjusting the weights to achieve balance. The weights are then adjusted to increase the mass

by the amount of sample wanted. Sample is then added until the balance just trips. Accurate masses are determined by the difference method described in question 4.

Answers to Experiment Questions

1. b: A centigram balance detects mass differences no smaller than 0.01 g, so accurate masses should be recorded to reflect that. No estimates should be made between the.01 marks.

2. c: Since direct weighings were done, either or both values could have balance errors included.

3. b: Since a balance reading represents ± .001 g, the two results of 28.774 g (direct) and 28.775 g (by difference) may be considered to be identical.

4. a: Weigh a group that is large enough to make the value to the left of the decimal 10 or greater. This increases the number of sig. figs in the total mass to five. When this is divided by a counting number to get the average, five sig. figs would be justified in the average mass.

5. This response will vary depending on the individual student results. The explanation will simply be a reference to the collected data.

6. b: After weighing the container, the mass reading is increased by an amount equal to the desired sample size. 0.71 g + 0.50 g = 1.21 g.

Student Results

1. The time required for our students to collect their data ranges from 1 hr, 30 minutes to 2 hr, 10 minutes. This time is influenced by the number of students in the lab and the number of balances made available. We often use surplus lab time to discuss the calculations.

2. Unknown masses: If the stockroom has done a good job of weighing the masses, the students usually get values done by difference that are correct to within ± 0.02 g(centigram balance) and ± 0.002 g (or 0.0002 g) for electronic balances.