

## Chapter 3 The Mole — The Central Unit of Chemistry — Answers

### 3.1 Relative Atomic Mass

#### Warm Up, p. 108

1. dozen, litres, kilograms
2. b. volume  
c. mass

#### Quick Check, p. 108

1. One object's mass relative to another's
2. You must have the same number of candies in each bag.

#### Practice Problems — Determining Relative Atomic Mass, p. 110

1.  $\frac{276 \text{ g}}{26.4 \text{ g}} = 10.5$   
The mass of an AA battery is 10.5 times the mass of a watch battery.
2.  $\frac{2.683 \text{ g Sr}}{0.490 \text{ g O}} = 5.48$   
A strontium atom weighs 5.48 times as much as an oxygen atom.
3. a.  $4.218 \text{ g DBr} - 0.337 \text{ g D} = 3.881 \text{ g Br}$   
 $\frac{0.337 \text{ g D}}{3.881 \text{ g Br}} \times 79.9 \text{ u} = 6.94 \text{ u}$   
b. Daltonium represents lithium.

#### Practice Problems — Determining Relative Atomic Mass (Non 1:1 Formulas), p. 111

1.  $3 \times \frac{1.000 \text{ g Al}}{14.100 \text{ g I}} \times 126.9 \text{ u} = 27.00 \text{ u}$
2.  $1.5 \times \frac{1.000 \text{ g Al}}{14.100 \text{ g I}} \times 126.9 \text{ u} = 13.5 \text{ u}$

### 3.1 Activity: The Relative Mass of Paper Clips, p. 112

For example:

| Objects             | Mass (g) |
|---------------------|----------|
| Small paper clips   | 5.6      |
| Coupled paper clips | 20.0     |
| Large paper clips   | 14.4     |

$$1. \frac{\text{Mass of some number of large paper clips}}{\text{Mass of the same number of small paper clips}} = \frac{14.4 \text{ g}}{5.6 \text{ g}} = 2.57$$

The mass of a large paper clip is 2.57 times the mass of a small paper clip.

$$4. 1.00 \text{ smu} \times 2.57 = 2.57 \text{ smu}$$

7. All the paper clips of the same type may not weigh exactly the same.

### 3.1 Review Questions, p. 113

$$1. \text{ a. } \frac{2245 \text{ g}}{825 \text{ g}} = 2.72 \quad 2.72 \times 1.00 \text{ mmu} = 2.72 \text{ mmu}$$

b. The mass ratio of any equal number of identical items is the same.

$$2. \text{ a. } 5.000 \text{ g NaCl} - 1.965 \text{ g Na} = 3.035 \text{ g Cl}$$
$$\frac{1.965 \text{ g Na}}{3.035 \text{ g Cl}} = 0.6474$$

$$\text{ b. } 0.6474 \times 35.5 \text{ u} = 23.0 \text{ u}$$

$$3. \text{ a. } 10.000 \text{ g ZuF} - 8.503 \text{ g Zu} = 1.497 \text{ g F}$$
$$\frac{8.503 \text{ g Zu}}{1.497 \text{ g F}} \times 19.0 \text{ u} = 108 \text{ u}$$

b. silver

$$4. \text{ a. } \frac{2.037 \text{ g Zn}}{1.000 \text{ g S}} \times 32.1 \text{ u} = 65.4 \text{ u}$$

$$\text{ b. } 2 \times \frac{2.037 \text{ g Zn}}{1.000 \text{ g S}} \times 32.1 \text{ u} = 130 \text{ u}$$

$$\text{ c. } 0.667 \times \frac{2.037 \text{ g Zn}}{1.000 \text{ g S}} \times 32.1 \text{ u} = 43.8 \text{ u}$$

5. a.  $\frac{13.073 \text{ g Cu}}{1.647 \text{ g O}} \times 16.0 \text{ u} = 127 \text{ u}$   
 b.  $0.50 \times \frac{13.073 \text{ g Cu}}{1.647 \text{ g O}} \times 16.0 \text{ u} = 63.5 \text{ u}$   
 c.  $2.00 \times \frac{13.073 \text{ g Cu}}{1.647 \text{ g O}} \times 16.0 \text{ u} = 254 \text{ u}$

6. a.  $\frac{25.0}{0.3864} = 64.7$

b.  $63.5 \text{ u} \quad \text{Cu}_2\text{O}$

7. Al  $\frac{25.0}{0.903} = 27.7$  (3% error)

Mg  $\frac{25.0}{1.05} = 23.8$  (-2% error)

Ag  $\frac{25.0}{0.23772} = 105$  (-3% error)

8.

| Element | Mass of Gas (g) | Relative Atomic Mass (u) |
|---------|-----------------|--------------------------|
| H       | 0.210           | 1.0                      |
| Cl      | 7.455           | <b>35.5</b>              |

9. A potassium atom weighs 39.1 times as much as a hydrogen atom.

10. a. 31.0 u  
 b. 40.1 u  
 c. 238 u

11. a.  $\frac{628.2 \text{ g}}{213.1 \text{ g}} = 2.948$

The mass of a knife is 2.948 times the mass of a fork.

b. If eight knives weigh 2.948 times as much as eight forks then one knife will weigh 2.948 times as much as one fork.

c. The average mass of a knife is 2.948 times the average mass of a fork.

12. For example: Weigh a pile containing one 10 g coin and two 20 g coins. If the pile weighs:

49 g then the 10 g coin is actually 9 g

48 g then the 20 g coin is actually 19 g

50 g then the 30 g coin is actually 29 g

## 3.2 Introducing the Mole — The Central Unit of Chemistry

### Warm Up, p. 115

1. the number of slurps per gulp
2.  $15 \text{ gulps} \times \frac{4 \text{ slurps}}{1 \text{ gulp}} = 60 \text{ slurps}$
3.  $20 \text{ slurps} \times \frac{1 \text{ gulp}}{5 \text{ slurps}} = 4 \text{ gulps}$

### Quick Check, p. 116

1. a. For example: They both represent a number.  
b. For example: A dozen is known to be 12 of anything whereas we don't know exactly how many things are in a mole.
2. 35.5 g
3. 32.1 g

### Practice Problems — Converting Moles to Number of Items, p. 117

1.  $3.5 \text{ mol Cr}^{3+} \times \frac{6.02 \times 10^{23} \text{ ions Cr}^{3+}}{1 \text{ mol Cr}^{3+}} = 2.1 \times 10^{24} \text{ ions Cr}^{3+}$
2.  $30.0 \text{ mol H}_2\text{O} \times \frac{6.02 \times 10^{23} \text{ molecules H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 1.81 \times 10^{25} \text{ molecules H}_2\text{O}$
3.  $0.023 \text{ mol Na} \times \frac{6.02 \times 10^{23} \text{ atoms Na}}{1 \text{ mol Na}} = 1.4 \times 10^{22} \text{ atoms Na}$

### Practice Problems — Converting Number of Items to Moles, p. 118

1.  $1.81 \times 10^{22} \text{ atoms Ar} \times \frac{1 \text{ mol Ar}}{6.02 \times 10^{23} \text{ atoms Ar}} = 0.0301 \text{ mol Ar}$
2.  $2.25 \times 10^{24} \text{ molecules CO}_2 \times \frac{1 \text{ mol CO}_2}{6.02 \times 10^{23} \text{ molecules CO}_2} = 3.74 \text{ mol CO}_2$
3.  $9.27 \times 10^{22} \text{ formula units NaCl} \times \frac{1 \text{ mol NaCl}}{6.02 \times 10^{23} \text{ formula units NaCl}} = 0.154 \text{ mol NaCl}$

### Practice Problems — Determining a Compound's Formula Mass and/or Molar Mass, p. 119

1.  $\text{NO}_2$        $1(14.0 \text{ u}) + 2(16.0 \text{ u}) = 46.0 \text{ u}$
2.  $\text{Na}_2\text{Cr}_2\text{O}_7$      $2(23.0 \text{ g}) + 2(52.0 \text{ g}) + 7(16.0 \text{ g}) = 262.0 \text{ g}$  or  $262.0 \text{ g/mol}$

$$3. \quad \text{Fe}_2\text{S}_3 \quad 2(55.8 \text{ g}) + 3(32.1 \text{ g}) = 207.9 \text{ g or } 207.9 \text{ g/mol}$$

### Practice Problems — Converting Moles to Mass, p. 120

$$1. \quad 2.65 \text{ mol NaCl} \times \frac{58.5 \text{ g NaCl}}{1 \text{ mol NaCl}} = 155 \text{ g NaCl}$$

$$2. \quad 0.87 \text{ mol NH}_3 \times \frac{17.0 \text{ g NH}_3}{1 \text{ mol NH}_3} = 15 \text{ g NH}_3$$

$$3. \quad 2.0 \times 10^{12} \text{ mol H}_2\text{SO}_4 \times \frac{98.1 \text{ g H}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1 \text{ kg H}_2\text{SO}_4}{1000 \text{ g H}_2\text{SO}_4} \times \frac{1 \text{ tonne H}_2\text{SO}_4}{1000 \text{ g H}_2\text{SO}_4} \\ = 2.0 \times 10^8 \text{ tonnes H}_2\text{SO}_4$$

### Practice Problems — Converting Mass to Moles, p. 120

$$1. \quad 62.2 \text{ g Au} \times \frac{1 \text{ mol Au}}{197.0 \text{ g Au}} = 0.316 \text{ mol Au}$$

$$2. \quad 3.88 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.0 \text{ g CO}_2} = 0.0882 \text{ mol CO}_2$$

$$3. \quad 500.0 \text{ mg (NH}_4)_2\text{CO}_3 \times \frac{1 \text{ g (NH}_4)_2\text{CO}_3}{1000 \text{ mg (NH}_4)_2\text{CO}_3} = 0.5000 \text{ g (NH}_4)_2\text{CO}_3$$

$$0.5000 \text{ g (NH}_4)_2\text{CO}_3 \times \frac{1 \text{ mol (NH}_4)_2\text{CO}_3}{96.0 \text{ g (NH}_4)_2\text{CO}_3} = 0.00521 \text{ mol (NH}_4)_2\text{CO}_3$$

### 3.2 Activity: A Mole of Pennies, p. 121

1. For example:  $8.6 \times 10^{17}$  km
2. For example:  $1.5 \times 10^{21}$  kg

### 3.2 Review Questions, p. 122

1. a. A quantity equal to the number of atoms in the atomic mass of any element expressed in grams  
b.  $6.02214179 \times 10^{23}$   
c. Avogadro's number
2. a. 12.0 g  
b. 36.0 g  
c. 64.2 g

3. a. 55.8 g  
b. molar mass
4. a. 44.0 u  
b. 74.1 u  
c. 154.0 g
5.  $3.2 \text{ mol C} \times \frac{6.02 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}} = 1.9 \times 10^{24} \text{ atoms C}$
6.  $0.0085 \text{ moles C}_2\text{H}_6 \times \frac{6.02 \times 10^{23} \text{ molecules C}_2\text{H}_6}{1 \text{ mol C}_2\text{H}_6} = 5.1 \times 10^{21} \text{ molecules C}_2\text{H}_6$
7.  $1.4 \times 10^{18} \text{ atoms Ag} \times \frac{1 \text{ mol Ag}}{6.02 \times 10^{23} \text{ atoms Ag}} = 2.3 \times 10^{-6} \text{ mol Ag}$
8.  $2.99 \text{ g Na} \times \frac{1 \text{ mol Na}}{23.0 \text{ g Na}} = 0.130 \text{ mol Na}$
9.  $5.2 \text{ mol F} \times \frac{19.0 \text{ g F}}{1 \text{ mol F}} = 99 \text{ g F}$
10.  $2.0 \text{ g Li} \times \frac{1 \text{ mol Li}}{6.9 \text{ g Li}} = 0.316 \text{ mol Li}$
11.  $0.32 \text{ mol NaNO}_2 \times \frac{69.0 \text{ g NaNO}_2}{1 \text{ mol NaNO}_2} = 22 \text{ g NaNO}_2$
12.  $0.058 \text{ g C}_8\text{H}_{10}\text{N}_4\text{O}_2 \times \frac{1 \text{ mol C}_8\text{H}_{10}\text{N}_4\text{O}_2}{194.0 \text{ g C}_8\text{H}_{10}\text{N}_4\text{O}_2} = 3.0 \times 10^{-4} \text{ mol C}_8\text{H}_{10}\text{N}_4\text{O}_2$
13.  $0.725 \text{ mol CO}_2 \times \frac{6.02 \times 10^{23} \text{ molecules CO}_2}{1 \text{ mol CO}_2} = 4.36 \times 10^{23} \text{ molecules CO}_2$
14.  $1.70 \times 10^9 \text{ molecules Pher} \times \frac{1 \text{ mol Pher}}{6.02 \times 10^{23} \text{ molecules Pher}} = 2.82 \times 10^{-15} \text{ mol Pher}$
15.  $1300 \text{ g Ti} \times \frac{1 \text{ mol Ti}}{47.9 \text{ g Ti}} = 27 \text{ mol Ti}$
16.  $1.75 \text{ mol CuSO}_4, 5\text{H}_2\text{O} \times \frac{249.6 \text{ g CuSO}_4, 5\text{H}_2\text{O}}{1 \text{ mol CuSO}_4, 5\text{H}_2\text{O}} = 437 \text{ g CuSO}_4, 5\text{H}_2\text{O}$

$$17. \quad 8.18 \times 10^6 \text{ mol NH}_3 \times \frac{17.0 \text{ g NH}_3}{1 \text{ mol NH}_3} \times \frac{1 \text{ tonne NH}_3}{1000 \text{ g NH}_3} = 1.39 \times 10^5 \text{ tonnes NH}_3$$

$$18. \quad 2.640 \times 10^3 \text{ g (NH}_4\text{)PO}_4 \times \frac{1 \text{ mol (NH}_4\text{)PO}_4}{47.9 \text{ g (NH}_4\text{)PO}_4} = 55 \text{ mol (NH}_4\text{)PO}_4$$

$$19. \quad 5.925 \text{ mol SnCr}_2\text{O}_7 \times \frac{334.7 \text{ g SnCr}_2\text{O}_7}{1 \text{ mol SnCr}_2\text{O}_7} = 1983 \text{ g SnCr}_2\text{O}_7$$

### 3.3 The Wheel Model of Mole Conversions

#### Warm Up, p. 124

- 15 g C
- 1 mol Zn
- 34 g CH<sub>4</sub>

#### Practice Problems — Two Step Conversions, p. 126

$$1. \quad 1 \times 10^{18} \text{ molecules SO}_2 \times \frac{1 \text{ mol SO}_2}{6.02 \times 10^{23} \text{ molecules SO}_2} \times \frac{64.1 \text{ g SO}_2}{1 \text{ mol SO}_2} = 1 \times 10^{-4} \text{ g SO}_2$$

$$2. \quad 2.1 \text{ g Br} \times \frac{1 \text{ mol Br}}{79.9 \text{ g Br}} \times \frac{6.02 \times 10^{23} \text{ atoms Br}}{1 \text{ mol Br}} = 1.6 \times 10^{22} \text{ atoms Br}$$

$$3. \quad 1 \text{ atom Ag} \times \frac{1 \text{ mol Ag}}{6.02 \times 10^{23} \text{ atoms Ag}} \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}} = 1.79 \times 10^{-22} \text{ g Ag}$$

#### Practice Problems — One-, Two-, and Three-Step Conversions, p. 128

$$1. \quad \text{a. } \frac{2 \text{ mol O}}{1 \text{ mol SO}_2} \quad \text{b. } \frac{1 \text{ mol C}_2\text{H}_4}{4 \text{ mol H}}$$

$$2. \quad 14 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} \times \frac{1 \text{ mol KNO}_3}{3 \text{ mol O}} = 0.29 \text{ mol KNO}_3$$

$$3. \quad 2.5 \text{ g K}_2\text{Cr}_2\text{O}_7 \times \frac{1 \text{ mol K}_2\text{Cr}_2\text{O}_7}{294.2 \text{ g K}_2\text{Cr}_2\text{O}_7} \times \frac{7 \text{ mol O}}{1 \text{ mol K}_2\text{Cr}_2\text{O}_7} \times \frac{6.02 \times 10^{23} \text{ atoms O}}{1 \text{ mol O}} \\ = 3.6 \times 10^{22} \text{ atoms O}$$

$$4. \quad 1.23 \times 10^{24} \text{ f.units Na}_2\text{S} \times \frac{1 \text{ mol Na}_2\text{S}}{6.02 \times 10^{23} \text{ f.units Na}_2\text{S}} \times \frac{2 \text{ mol Na}^+}{1 \text{ mol Na}_2\text{S}} \times \frac{23.0 \text{ g Na}^+}{1 \text{ mol Na}^+} \\ = 94.0 \text{ g Na}^+$$

### 3.3 Activity: The Evaporation Rate of Water, p. 129

For example:

|                | Mass of Beaker and H <sub>2</sub> O (g) | Time of Day |
|----------------|---|-------------|
| <b>initial</b> | 68.623                                  | 8:50        |
| <b>final</b>   | 68.555                                  | 9:20        |
| <b>change</b>  | 0.068                                   | 30 min      |

- $$0.068 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.0 \text{ g H}_2\text{O}} \times \frac{6.02 \times 10^{23} \text{ molecules H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 2.274 \times 10^{21} \text{ molecules H}_2\text{O}$$
- $$30 \text{ min} \times \frac{60 \text{ s}}{1 \text{ min}} = 1800 \text{ s}$$
- $$\frac{2.274 \times 10^{21} \text{ molecules H}_2\text{O}}{1800 \text{ s}} = 1 \times 10^{18} \text{ molecules H}_2\text{O}$$

### 3.3 Review Questions, p. 130

- $$1.0 \times 10^3 \text{ atoms Ag} \times \frac{1 \text{ mol Ag}}{6.02 \times 10^{23} \text{ atoms Ag}} \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}} = 1.8 \times 10^{-19} \text{ g Ag}$$
- $$106.0 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} \times \frac{6.02 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}} = 5.32 \times 10^{24} \text{ atoms C}$$
- $$1 \text{ atom Cl} \times \frac{1 \text{ mol Cl}}{6.02 \times 10^{23} \text{ atoms Cl}} \times \frac{35.5 \text{ g Cl}}{1 \text{ mol Cl}} = 5.90 \times 10^{-23} \text{ g Cl}$$
- $$72.6 \text{ g C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{44.0 \text{ g C}_3\text{H}_8} \times \frac{6.02 \times 10^{23} \text{ molecules C}_3\text{H}_8}{1 \text{ mol C}_3\text{H}_8} = 9.93 \times 10^{23} \text{ molecules C}_3\text{H}_8$$
- $$31.1 \text{ g Au} \times \frac{1 \text{ mol Au}}{197.0 \text{ g Au}} \times \frac{6.02 \times 10^{23} \text{ atoms Au}}{1 \text{ mol Au}} = 9.50 \times 10^{22} \text{ atoms Au}$$
  - $$\frac{9.50 \times 10^{22} \text{ atoms Au}}{1.3 \times 10^5 \text{ cents}} = 7.3 \times 10^{17} \text{ atoms Au per cent}$$
- $$\frac{4 \text{ mol O}}{1 \text{ mol N}_2\text{O}_4}$$
  - $$\frac{1 \text{ mol NO}_2}{1 \text{ mol N}}$$



7.  $2.3 \text{ mol CO}_2 \times \frac{2 \text{ mol O}}{1 \text{ mol CO}_2} = 4.6 \text{ mol O}$
8.  $52.4 \text{ mg CaC}_2\text{O}_4 \times \frac{1 \text{ g CaC}_2\text{O}_4}{1000 \text{ mg CaC}_2\text{O}_4} = 0.0524 \text{ g CaC}_2\text{O}_4$   
 $0.0524 \text{ g CaC}_2\text{O}_4 \times \frac{1 \text{ mol CaC}_2\text{O}_4}{128.1 \text{ g CaC}_2\text{O}_4} \times \frac{2 \text{ mol C}}{1 \text{ mol CaC}_2\text{O}_4} = 8.18 \times 10^{-4} \text{ mol C}$
9.  $6.80 \times 10^{24} \text{ f.units Na}_3\text{PO}_4 \times \frac{1 \text{ mol Na}_3\text{PO}_4}{6.02 \times 10^{23} \text{ f.units Na}_3\text{PO}_4} \times \frac{3 \text{ mol Na}^+}{1 \text{ mol Na}_3\text{PO}_4}$   
 $= 33.9 \text{ mol Na}^+$
10.  $1.4 \text{ mol O} \times \frac{1 \text{ mol H}_2\text{SO}_4}{4 \text{ mol O}} \times \frac{98.1 \text{ g H}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} = 34 \text{ g H}_2\text{SO}_4$
11.  $0.85 \text{ mol C}_8\text{H}_9\text{NO}_2 \times \frac{8 \text{ mol C}}{1 \text{ mol C}_8\text{H}_9\text{NO}_2} \times \frac{6.02 \times 10^{23} \text{ atoms C}}{1 \text{ mol C}} = 4.1 \times 10^{24} \text{ atoms C}$
12.  $100.0 \text{ g HgCl}_2 \times \frac{1 \text{ mol HgCl}_2}{271.6 \text{ g HgCl}_2} \times \frac{1 \text{ mol Hg}^{2+}}{1 \text{ mol HgCl}_2} \times \frac{6.02 \times 10^{23} \text{ ions Hg}^{2+}}{1 \text{ mol Hg}^{2+}}$   
 $= 2.22 \times 10^{23} \text{ ions Hg}^{2+}$
13.  $8.3 \text{ g CuCl}_2 \times \frac{1 \text{ mol CuCl}_2}{134.5 \text{ g CuCl}_2} \times \frac{2 \text{ mol Cl}^-}{1 \text{ mol CuCl}_2} \times \frac{35.5 \text{ g Cl}^-}{1 \text{ mol Cl}^-} = 4.4 \text{ g Cl}^-$
14.  $4.8 \times 10^{26} \text{ molecules C}_2\text{H}_5\text{OH} \times \frac{1 \text{ mol C}_2\text{H}_5\text{OH}}{6.02 \times 10^{23} \text{ molecules C}_2\text{H}_5\text{OH}} \times \frac{2 \text{ mol C}}{1 \text{ mol C}_2\text{H}_5\text{OH}} \times \frac{12.0 \text{ g C}}{1 \text{ mol C}}$   
 $= 1.9 \times 10^4 \text{ g C} = 19 \text{ kg C}$
15.  $3.9 \times 10^{27} \text{ molecules HF} \times \frac{1 \text{ mol HF}}{6.02 \times 10^{23} \text{ molecules HF}} \times \frac{20.0 \text{ g HF}}{1 \text{ mol HF}} \times \frac{1 \text{ kg HF}}{1000 \text{ g HF}}$   
 $= 1.3 \times 10^2 \text{ kg HF}$
16.  $1.44 \times 10^8 \text{ g NO}_2 \times \frac{1 \text{ mol NO}_2}{46.0 \text{ g NO}_2} \times \frac{2 \text{ mol O}}{1 \text{ mol NO}_2} \times \frac{6.02 \times 10^{23} \text{ atoms O}}{1 \text{ mol O}}$   
 $= 3.77 \times 10^{30} \text{ atoms O}$
17.  $1.000 \times 10^{-3} \text{ g CCl}_4 \times \frac{1 \text{ mol CCl}_4}{154.0 \text{ g CCl}_4} \times \frac{6.02 \times 10^{23} \text{ molecules CCl}_4}{1 \text{ mol CCl}_4}$   
 $= 3.91 \times 10^{18} \text{ molecules CCl}_4$

$$18. \quad 4.5 \text{ mol C}_3\text{H}_5(\text{OH})_3 \times \frac{8 \text{ mol H}}{1 \text{ mol C}_3\text{H}_5(\text{OH})_3} \times \frac{6.02 \times 10^{23} \text{ atoms H}}{1 \text{ mol H}} = 2.2 \times 10^{25} \text{ atoms H}$$

$$19. \quad 14.56 \text{ g NaHSO}_4 \times \frac{1 \text{ mol NaHSO}_4}{120.1 \text{ g NaHSO}_4} \times \frac{7 \text{ mol atoms}}{1 \text{ mol NaHSO}_4} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol atoms}} \\ = 5.11 \times 10^{23} \text{ atoms}$$

### 3.4 Molar Volume

#### Warm Up, p. 132

1. thousandth
2. millimoles (mmol)
3. litre
4. 32 mL
5. 0.0112 g

#### Quick Check, p. 132

- |  |              |
|--|--------------|
| 1. the volume of the mole of a substance | 3. spacing   |
| 2. size, spacing                         | 4. increases |

#### Practice Problems — Converting Moles to Volume or Volume to Moles, p. 134

1.  $1.33 \text{ mol O}_2 \times \frac{22.4 \text{ L O}_2}{1 \text{ mol O}_2} = 29.8 \text{ L O}_2$
2.  $9.5 \text{ L SO}_2 \times \frac{1 \text{ mol SO}_2}{22.4 \text{ L SO}_2} = 0.42 \text{ mol SO}_2$
3.  $0.39 \text{ mol SiO}_2 \times \frac{22.8 \text{ cm}^3 \text{ SiO}_2}{1 \text{ mol SiO}_2} = 8.9 \text{ cm}^3 \text{ SiO}_2$

#### Practice Problems — Conversions: Volume to Number of Items or Mass; Mass to Volume, p. 136

1.  $17 \text{ g H}_2\text{S} \times \frac{1 \text{ mol H}_2\text{S}}{34.1 \text{ g H}_2\text{S}} \times \frac{22.4 \text{ L H}_2\text{S}}{1 \text{ mol H}_2\text{S}} = 11 \text{ L H}_2\text{S}$
2. 22.4 L C<sub>3</sub>H<sub>8</sub>, 3 mol C, 12.0 g C     answer 1.6 g C

$$3. \quad 0.200 \text{ L C}_2\text{H}_6\text{O}_2 \times \frac{1 \text{ mol C}_2\text{H}_6\text{O}_2}{0.0559 \text{ L C}_2\text{H}_6\text{O}_2} \times \frac{6 \text{ mol H}}{1 \text{ mol C}_2\text{H}_6\text{O}_2} \times \frac{6.02 \times 10^{23} \text{ atoms H}}{1 \text{ mol H}}$$

$$= 1.29 \times 10^{25} \text{ atoms H}$$

### Practice Problems — Calculating Molar Volume and Density, p. 138

- $1.33 \text{ g Au} \times \frac{1 \text{ cm}^3 \text{ Au}}{19.42 \text{ g Au}} = 639 \text{ cm}^3 \text{ Au}$
- $12.7 \text{ mL Hg} \times \frac{13.534 \text{ g Hg}}{1 \text{ mL Hg}} = 172 \text{ g Hg}$
- $\frac{46.0 \text{ g C}_2\text{H}_5\text{OH}}{1 \text{ mol C}_2\text{H}_5\text{OH}} \times \frac{1 \text{ mL C}_2\text{H}_5\text{OH}}{0.789 \text{ g C}_2\text{H}_5\text{OH}} = 58.3 \text{ mL/mol C}_2\text{H}_5\text{OH}$

### 3.4 Activity: The Atomic Radius of Aluminum, p. 139

- $2.702 \text{ g/cm}^3$
- $\frac{27.0 \text{ g Al}}{1 \text{ mol Al}} \times \frac{1 \text{ cm}^3 \text{ Al}}{2.702 \text{ g Al}} = 9.99 \text{ cm}^3/\text{mol Al}$
- $0.74 \times \frac{9.99 \text{ cm}^3 \text{ Al}}{1 \text{ mol Al}} = 7.3945 \text{ cm}^3/\text{mol Al}$
- $\frac{7.3945 \text{ cm}^3 \text{ Al}}{1 \text{ mol Al}} \times \frac{1 \text{ mol Al}}{6.02 \times 10^{23} \text{ atoms Al}} = 1.228 \times 10^{-23} \text{ cm}^3/\text{atom Al}$
- $r^3 = \frac{1.228 \times 10^{-23} \text{ cm}^3}{4.1888} = 2.93 \times 10^{-24} \text{ cm}^3 \quad r = 1.43 \times 10^{-8} \text{ cm}$
- $1.43 \times 10^{-8} \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \times 10^9 \text{ nm}}{1 \text{ m}} = 0.143 \text{ nm}$

### 3.4 Review Questions, p. 140

- $0.250 \text{ mol C}_8\text{H}_{18} \times \frac{82.4 \text{ mL C}_8\text{H}_{18}}{1 \text{ mol C}_8\text{H}_{18}} = 20.6 \text{ mL C}_8\text{H}_{18}$
- $2.4 \text{ L air} \times \frac{1 \text{ mol air}}{22.4 \text{ L air}} = 0.11 \text{ mol air}$

3.  $2.75 \text{ L N}_2 \times \frac{1 \text{ mol N}_2}{22.4 \text{ L N}_2} = 0.123 \text{ mol N}_2$
4.  $5.0 \text{ L air} \times \frac{21 \text{ L O}_2}{100 \text{ L air}} \times \frac{1 \text{ mol O}_2}{22.4 \text{ L O}_2} = 0.047 \text{ mol O}_2$
5.  $2.57 \text{ L P}_2\text{O}_5 \times \frac{1 \text{ mol P}_2\text{O}_5}{22.4 \text{ L P}_2\text{O}_5} \times \frac{142.0 \text{ g P}_2\text{O}_5}{1 \text{ mol P}_2\text{O}_5} = 16.3 \text{ g P}_2\text{O}_5$
6.  $\frac{0.935 \text{ g}}{525 \text{ mL}} \times \frac{22400 \text{ mL}}{1 \text{ mol}} = 39.9 \text{ g/mol (Argon)}$
7.  $1400 \text{ L C}_2\text{H}_2 \times \frac{1 \text{ mol C}_2\text{H}_2}{22.4 \text{ L C}_2\text{H}_2} \times \frac{6.02 \times 10^{23} \text{ molecules C}_2\text{H}_2}{1 \text{ mol C}_2\text{H}_2} = 3.8 \times 10^{25} \text{ molecules C}_2\text{H}_2$
8.  $5 \times 10^{19} \text{ molecules PH}_3 \times \frac{1 \text{ mol PH}_3}{6.02 \times 10^{23} \text{ molecules PH}_3} \times \frac{22.4 \text{ L PH}_3}{1 \text{ mol PH}_3} = 0.002 \text{ L PH}_3$   
 $0.002 \text{ L PH}_3 \times \frac{1000 \text{ mL}}{1 \text{ L}} = 2 \text{ mL PH}_3$
9.  $9100 \text{ g C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{44.0 \text{ g C}_3\text{H}_8} \times \frac{22.4 \text{ L C}_3\text{H}_8}{1 \text{ mol C}_3\text{H}_8} = 4600 \text{ L C}_3\text{H}_8$
10.  $(3.7) 0.355 \text{ L CO}_2 \times \frac{1 \text{ mol CO}_2}{22.4 \text{ L CO}_2} \times \frac{44.0 \text{ g CO}_2}{1 \text{ mol CO}_2} = 2.6 \text{ g CO}_2$
11.  $83.9 \text{ L NH}_3 \times \frac{1 \text{ mol NH}_3}{22.4 \text{ L NH}_3} \times \frac{3 \text{ mol H}}{1 \text{ mol NH}_3} = 11.2 \text{ mol H}$
12.  $3.84 \text{ L N}_2\text{O} \times \frac{1 \text{ mol N}_2\text{O}}{22.4 \text{ L N}_2\text{O}} \times \frac{2 \text{ mol N}}{1 \text{ mol N}_2\text{O}} \times \frac{14.0 \text{ g N}}{1 \text{ mol N}} = 4.80 \text{ g N}$
13.  $27.2 \text{ L N}_2\text{O}_4 \times \frac{1 \text{ mol N}_2\text{O}_4}{22.4 \text{ L N}_2\text{O}_4} \times \frac{4 \text{ mol O}}{1 \text{ mol N}_2\text{O}_4} \times \frac{6.02 \times 10^{23} \text{ atoms O}}{1 \text{ mol O}}$   
 $= 2.92 \times 10^{24} \text{ atoms O}$
14.  $15 \text{ mL C}_4\text{H}_{10} \times \frac{0.601 \text{ g C}_4\text{H}_{10}}{1 \text{ mL C}_4\text{H}_{10}} = 9.0 \text{ g C}_4\text{H}_{10}$
15.  $\frac{200.6 \text{ g Hg}}{1 \text{ mol Hg}} \times \frac{1 \text{ mL Hg}}{13.546 \text{ g Hg}} = 14.81 \text{ mL/mol Hg}$

16.  $5.0 \text{ cm}^3 \text{ Au} \times \frac{19.42 \text{ g Au}}{1 \text{ cm}^3 \text{ Au}} \times \frac{1 \text{ mol Au}}{197.0 \text{ g Au}} = 0.49 \text{ mol Au}$
17.  $15.0 \text{ mL Br}_2 \times \frac{3.53 \text{ g Br}_2}{1 \text{ mL Br}_2} \times \frac{1 \text{ mol Br}_2}{159.8 \text{ g Br}_2} \times \frac{6.02 \times 10^{23} \text{ molecules Br}_2}{1 \text{ mol Br}_2}$   
 $= 1.99 \times 10^{23} \text{ molecules Br}_2$

### 3.5 Composition Analysis — Determining Formulas

#### Warm Up, p. 142

- 72 u
- 29u
- For example: more ways of creating the fragment  
 For example: weaker bonds are broken to create fragment

#### Practice Problems — Determining Percentage Composition, p. 143

- |      |                   |                     |                |
|------|-------------------|---------------------|----------------|
| 13 C | (13 × 12.0 g)/mol | = 156.0 g/mol       | = 75.7%        |
| 18 H | (18 × 1.0 g)/mol  | = 18.0 g/mol        | = 8.7%         |
| 2 O  | (2 × 16.0 g)/mol  | = <u>32.0 g/mol</u> | = <u>15.5%</u> |
|      |                   | 206.0 g/mol         | 99.9%          |
- |     |                  |                     |                |
|-----|------------------|---------------------|----------------|
| 2 N | (2 × 14.0 g)/mol | = 28.0 g/mol        | = 21.2%        |
| 8 H | (8 × 1.0 g)/mol  | = 18.0 g/mol        | = 6.1%         |
| 1 S | (1 × 32.0 g)/mol | = 32.1 g/mol        | = 24.3%        |
| 4 O | (4 × 16.0 g)/mol | = <u>64.0 g/mol</u> | = <u>48.4%</u> |
|     |                  | 132.1 g/mol         | 100.0%         |
- |                    |                  |                      |         |
|--------------------|------------------|----------------------|---------|
| 1 Mg               | (1 × 24.3 g)/mol | = 24.3 g/mol         |         |
| 1 S                | (1 × 32.0 g)/mol | = 32.1 g/mol         |         |
| 4 O                | (4 × 16.0 g)/mol | = <u>64.0 g/mol</u>  |         |
|                    |                  | 120.4 g/mol          |         |
| 7 H <sub>2</sub> O | (7 × 18.0 g)/mol | = <u>126.0 g/mol</u> | = 51.1% |
|                    |                  | 246.4 g/mol          |         |

Quick Check, p. 144

| Structural Formula  | Molecular Formula                | Empirical Formula     |
|---|----------------------------------|-----------------------|
| $  \begin{array}{c}  \text{H} \quad \text{O} \\    \quad    \\  \text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\    \\  \text{H}  \end{array}  $ | $\text{C}_2\text{H}_4\text{O}_2$ | $\text{CH}_2\text{O}$ |
| $  \begin{array}{c}  \text{O} \quad \text{O} \\     \quad    \\  \text{H} - \text{O} - \text{C} - \text{C} - \text{O} - \text{H}  \end{array}  $        | $\text{C}_2\text{H}_2\text{O}_4$ | $\text{CHO}_2$        |

Practice Problems — Determining an Empirical Formula, p. 145

$$1. \quad 18.7 \text{ g Li} \times \frac{1 \text{ mol Li}}{6.9 \text{ g Li}} = 2.7101 \text{ mol Li}$$

$$16.3 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 1.3583 \text{ mol C}$$

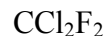
$$65.5 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 4.0938 \text{ mol O}$$



$$2. \quad 9.93 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 0.8275 \text{ mol C}$$

$$58.6 \text{ g Cl} \times \frac{1 \text{ mol Cl}}{35.5 \text{ g Cl}} = 1.6507 \text{ mol Cl}$$

$$31.4 \text{ g F} \times \frac{1 \text{ mol F}}{19.0 \text{ g F}} = 1.6526 \text{ mol F}$$



$$3. \quad 5.723 \text{ g Ag} \times \frac{1 \text{ mol Ag}}{107.9 \text{ g Ag}} = 0.0531 \text{ mol Ag}$$

$$0.852 \text{ g S} \times \frac{1 \text{ mol S}}{32.1 \text{ g S}} = 0.0265 \text{ mol S}$$

$$1.695 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 0.1059 \text{ mol O}$$



**Practice Problems — Determining a Molecular Formula, p. 147**

$$\begin{array}{l}
 1. \quad 1\text{C} \quad (1 \times 12.0 \text{ g})/\text{mol} = 12.0 \text{ g/mol} \\
 \quad \quad 2\text{H} \quad (2 \times 1.0 \text{ g})/\text{mol} = 2.0 \text{ g/mol} \\
 \quad \quad 1\text{O} \quad (1 \times 16.0 \text{ g})/\text{mol} = \frac{16.0 \text{ g/mol}}{30.0 \text{ g/mol}} \qquad \frac{60.0 \text{ g/mol}}{30.0 \text{ g/mol}} = 2 \\
 \quad \quad 2(\text{CH}_2\text{O}) = \text{C}_2\text{H}_4\text{O}_2
 \end{array}$$

$$\begin{array}{l}
 2. \quad 3\text{C} \quad (1 \times 12.0 \text{ g})/\text{mol} = 36.0 \text{ g/mol} \\
 \quad \quad 4\text{H} \quad (4 \times 1.0 \text{ g})/\text{mol} = \frac{4.0 \text{ g/mol}}{40.0 \text{ g/mol}}
 \end{array}$$

80.0 g/mol, 120.0 g/mol because they are both multiples of 40 g/mol

$$3. \quad 4.51 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 0.3758 \text{ mol C}$$

$$1.13 \text{ g H} \times \frac{1 \text{ mol H}}{1.0 \text{ g H}} = 1.13 \text{ mol H}$$

$$6.01 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 0.3756 \text{ mol O}$$

CH<sub>3</sub>O

$$\begin{array}{l}
 1\text{C} \quad (1 \times 12.0 \text{ g})/\text{mol} = 12.0 \text{ g/mol} \\
 3\text{H} \quad (3 \times 1.0 \text{ g})/\text{mol} = 3.0 \text{ g/mol} \\
 1\text{O} \quad (1 \times 16.0 \text{ g})/\text{mol} = \frac{16.0 \text{ g/mol}}{31.0 \text{ g/mol}} \qquad \frac{62.0 \text{ g/mol}}{31.0 \text{ g/mol}} = 2 \\
 2(\text{CH}_3\text{O}) = \text{C}_2\text{H}_6\text{O}_2
 \end{array}$$

**3.5 Activity: Determining the Empirical Formula of Butane from the Percentage Composition of Its Model, p. 148**

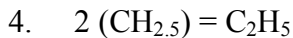
1. For example:

$$19.202 \text{ g C} \times \frac{1 \text{ doz C}}{14.4 \text{ g C}} = 1.3335 \text{ doz C}$$

$$18.733 \text{ g H} \times \frac{1 \text{ doz H}}{5.6 \text{ g H}} = 3.3452 \text{ doz H}$$

$$2. \quad \frac{3.3452 \text{ doz H}}{1.3335 \text{ doz C}} = 2.5 \qquad \text{CH}_{2.5}$$

3. 2



### 3.5 Review Questions, p. 149

$$\begin{array}{rcl} 1. & 10 \text{ C } (10 \times 12.0 \text{ g})/\text{mol} & = 120.0 \text{ g/mol} & = 76.9\% \\ & 20 \text{ H } (20 \times 1.0 \text{ g})/\text{mol} & = 20.0 \text{ g/mol} & = 12.8\% \\ & 1 \text{ O } (1 \times 16.0 \text{ g})/\text{mol} & = \underline{16.0 \text{ g/mol}} & = \underline{10.3\%} \\ & & 156.0 \text{ g/mol} & 100.0\% \end{array}$$

$$\begin{array}{rcl} 2. & 1 \text{ Na } (1 \times 23.0 \text{ g})/\text{mol} & = 23.0 \text{ g/mol} \\ & 2 \text{ C } (2 \times 12.0 \text{ g})/\text{mol} & = 24.0 \text{ g/mol} \\ & 3 \text{ H } (3 \times 1.0 \text{ g})/\text{mol} & = 3.0 \text{ g/mol} \\ & 2 \text{ O } (2 \times 16.0 \text{ g})/\text{mol} & = \underline{32.0 \text{ g/mol}} \\ & & 82.0 \text{ g/mol} \\ & 3\text{H}_2\text{O } (3 \times 18.0 \text{ g})/\text{mol} & = \underline{54.0 \text{ g/mol}} & = 39.7\% \\ & & 136.0 \text{ g/mol} \end{array}$$

$$\begin{array}{rcl} 3. & 7 \text{ C } (7 \times 12.0 \text{ g})/\text{mol} & = 84.0 \text{ g/mol} \\ & 5 \text{ H } (5 \times 1.0 \text{ g})/\text{mol} & = 5.0 \text{ g/mol} \\ & 6 \text{ O } (6 \times 16.0 \text{ g})/\text{mol} & = 96.0 \text{ g/mol} \\ & 3 \text{ N } (3 \times 14.0 \text{ g})/\text{mol} & = \underline{42.0 \text{ g/mol}} & = 18.5\% \\ & & 227 \text{ g/mol} \end{array}$$

4.

| Structural Formula   | Molecular Formula                | Empirical Formula              |
|--|----------------------------------|--------------------------------|
| $\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   \\ \text{H} - \text{C} - & \text{C} - & \text{C} - & \text{C} - \text{H} \\   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$            | $\text{C}_4\text{H}_{10}$        | $\text{C}_2\text{H}_5$         |
| $\begin{array}{cccc} & \text{O} & \text{H} & \text{H} & \text{H} \\ &    &   &   &   \\ \text{H} - \text{O} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - \text{H} \\ &   &   &   & \\ & \text{H} & \text{H} & \text{H} & \end{array}$ | $\text{C}_4\text{H}_8\text{O}_2$ | $\text{C}_2\text{H}_4\text{O}$ |

5. a. Many compounds have the same empirical formula  
b. Its molar mass





$$7. \quad 1.4844 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 0.1237 \text{ mol C}$$

$$0.1545 \text{ g H} \times \frac{1 \text{ mol H}}{1.0 \text{ g H}} = 0.1545 \text{ mol H}$$

$$0.4947 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 0.0309 \text{ mol O}$$

$$0.8661 \text{ g N} \times \frac{1 \text{ mol N}}{14.0 \text{ g N}} = 0.0619 \text{ mol N}$$



$$8. \quad 0.0285 \text{ mol Al} \times \frac{27.0 \text{ g Al}}{1 \text{ mol Al}} = 0.7695 \text{ g Al} = 1.8\% \text{ Al}$$

$$0.8740 \text{ mol Si} \times \frac{28.1 \text{ g Si}}{1 \text{ mol Si}} = 24.5594 \text{ g Si} = 58.2\% \text{ Si}$$

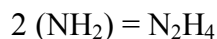
$$0.0975 \text{ mol Yb} \times \frac{173.0 \text{ g Yb}}{1 \text{ mol Yb}} = 16.8675 \text{ g Yb} = \frac{40.0\% \text{ Yb}}{100.0\%}$$

b. For example: If Helium was introduced in 1984, the person did not die before 1984 or perhaps Helium was only used in certain countries.

$$9. \quad 1 \text{ N} \quad (1 \times 14.0 \text{ g})/\text{mol} = 14.0 \text{ g/mol}$$

$$2 \text{ H} \quad (2 \times 1.0 \text{ g})/\text{mol} = \frac{2.0 \text{ g/mol}}{16.0 \text{ g/mol}}$$

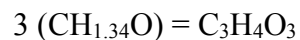
$$\frac{32.1 \text{ g/mol}}{16.0 \text{ g/mol}} = 2.01$$



$$10. \quad 1.080 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 0.090 \text{ mol C}$$

$$0.121 \text{ g H} \times \frac{1 \text{ mol H}}{1.0 \text{ g H}} = 0.121 \text{ mol H}$$

$$1.439 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 0.090 \text{ mol O}$$



$$3 \text{ C} \quad (3 \times 12.0 \text{ g})/\text{mol} = 36.0 \text{ g/mol}$$

$$\begin{array}{rcl}
 4 \text{ H} & (4 \times 1.0 \text{ g})/\text{mol} & = 4.0 \text{ g/mol} \\
 3 \text{ O} & (3 \times 16.0 \text{ g})/\text{mol} & = \frac{48.0 \text{ g/mol}}{88.0 \text{ g/mol}} \\
 2 (\text{C}_3\text{H}_4\text{O}_3) & = \text{C}_6\text{H}_8\text{O}_6 & \frac{176.1 \text{ g/mol}}{88.0 \text{ g/mol}} = 2.00
 \end{array}$$

$$11. \quad 92.29 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 7.69 \text{ mol C}$$

$$7.71 \text{ g H} \times \frac{1 \text{ mol H}}{1.0 \text{ g H}} = 7.71 \text{ mol H} \quad \text{CH}$$

$$\begin{array}{rcl}
 1 \text{ C} & (1 \times 12.0 \text{ g})/\text{mol} & = 12.0 \text{ g/mol} \\
 1 \text{ H} & (1 \times 1.0 \text{ g})/\text{mol} & = \frac{1.0 \text{ g/mol}}{13.0 \text{ g/mol}} \\
 6 (\text{CH}) & = \text{C}_6\text{H}_6 & \frac{78.0 \text{ g/mol}}{13.0 \text{ g/mol}} = 6.00
 \end{array}$$

12. a.  $0.273 \times 44.0\text{u} = 12.0\text{u}$   
 b. Yes, this is carbon's atomic mass.

### 3.6 Molar Concentration

#### Warm Up, p. 151

- For example: pop, apple juice, vinegar
- For example: vitamins, calcium ions, acids
- For example: bathroom, garage

#### Quick Check, p. 152

- For example: Many chemicals are dispensed in solution.  
For example: Most chemical reactions occur in solution.
- 2 mol of NaOH per litre of solution
- Molar concentrations allow chemists to directly compare the number of particles in the same volume of different solutions.

#### Practice Problems — Converting Moles of Solute into Volume of Solution, p. 153

$$1. \quad 0.72 \text{ L soln} \times \frac{2.5 \text{ mol NaOH}}{1 \text{ L soln}} = 1.8 \text{ mol NaOH}$$

- $0.500 \text{ L soln} \times \frac{0.154 \text{ mol NaCl}}{1 \text{ L soln}} = 0.0770 \text{ mol NaCl}$
- $3.0 \text{ mol HCl} \times \frac{1 \text{ L soln}}{0.60 \text{ mol HCl}} = 5.0 \text{ L soln}$
- $1.0 \times 10^{-3} \text{ mol methanethiol} \times \frac{1 \text{ L urine}}{4.0 \times 10^{-8} \text{ mol methanethiol}} = 25000 \text{ L urine}$

**Practice Problems — Converting Volume of Solution into Mass of Solute and Determining Molar Concentration, p. 154**

- $0.500 \text{ L soln} \times \frac{1.5 \text{ mol CaCl}_2}{1 \text{ L soln}} \times \frac{111.1 \text{ g CaCl}_2}{1 \text{ mol CaCl}_2} = 83 \text{ g CaCl}_2$

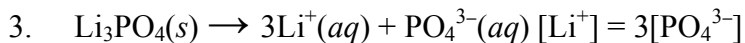
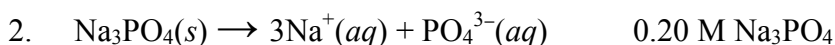
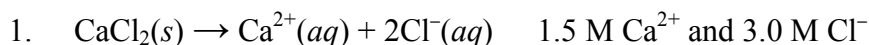
Measure out 83 g CaCl<sub>2</sub> and add water up to 0.500 L soln.

- $0.055 \text{ L soln} \times \frac{0.20 \text{ mol KCl}}{1 \text{ L soln}} \times \frac{74.6 \text{ g KCl}}{1 \text{ mol KCl}} = 0.82 \text{ g KCl}$

- $1.8 \text{ g AgNO}_3 \times \frac{1 \text{ mol AgNO}_3}{169.0 \text{ g AgNO}_3} = 0.01059 \text{ mol AgNO}_3$

$$\frac{0.01059 \text{ mol AgNO}_3}{0.075 \text{ L soln}} = 0.14 \text{ M AgNO}_3$$

**Practice Problems — Three-Step Conversion: Volume of Solution to Number of Ions, p. 157**



- $0.75 \text{ L soln} \times \frac{2.8 \text{ mol K}^+}{1 \text{ L soln}} \times \frac{39.1 \text{ g K}^+}{1 \text{ mol K}^+} = 82 \text{ g K}^+$

- $0.525 \text{ L soln} \times \frac{3.0 \text{ mol Fe(NO}_3)_3}{1 \text{ L soln}} \times \frac{3 \text{ mol NO}_3^-}{1 \text{ mol Fe(NO}_3)_3} \times \frac{6.02 \times 10^{23} \text{ ions NO}_3^-}{1 \text{ mol NO}_3^-}$   
 $= 2.8 \times 10^{24} \text{ ions NO}_3^-$

### 3.6 Activity: Building a Scale Model of a Solution, p. 158

- $$\frac{1000 \text{ g H}_2\text{O}}{1 \text{ L H}_2\text{O}} \times \frac{1 \text{ mol H}_2\text{O}}{18.0 \text{ g H}_2\text{O}} = \frac{55.6 \text{ mol H}_2\text{O}}{1 \text{ L H}_2\text{O}}$$
- 1 M Na<sup>+</sup>, 1 M Cl<sup>-</sup>
- 54 H<sub>2</sub>O, 1 Na<sup>+</sup>, 1 Cl<sup>-</sup>
- Note to teacher: Airsoft B.B.'s are not too expensive (6 mm dia.)  
If you want the particle sizes to be roughly to scale then the Cl<sup>-</sup> ions should be double the diameter of the Na<sup>+</sup> ions and the H<sub>2</sub>O molecules.
- For example: The particles are not moving in the model  
For example: The particles are much larger in the model  
For example: The particles in the model appear to be solid as opposed to having a cloud like shell

### 3.6 Review Questions, 159

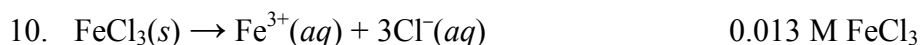
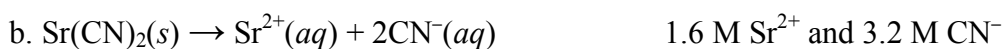
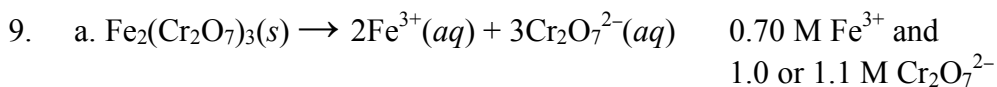
- 1.5 mol HCl per 1 L soln
- $$0.0050 \text{ L DM} \times \frac{0.011 \text{ mol DM}}{1 \text{ L syrup}} = 5.5 \times 10^{-5} \text{ mol DM}$$
- $$0.075 \text{ mol Ca}^{2+} \times \frac{1 \text{ L soln}}{0.20 \text{ mol Ca}^{2+}} = 0.37 \text{ or } 0.38 \text{ L soln}$$
- $$5.00 \times 10^{-13} \text{ L soln} \times \frac{1.2 \times 10^{-2} \text{ mol Na}^+}{1 \text{ L soln}} \times \frac{6.02 \times 10^{23} \text{ ions Na}^+}{1 \text{ mol Na}^+} = 3.6 \times 10^9 \text{ ions Na}^+$$
- a. 
$$0.10 \text{ g C}_8\text{H}_{10}\text{N}_4\text{O}_2 \times \frac{1 \text{ mol C}_8\text{H}_{10}\text{N}_4\text{O}_2}{194.0 \text{ g C}_8\text{H}_{10}\text{N}_4\text{O}_2} = 5.155 \times 10^{-4} \text{ mol C}_8\text{H}_{10}\text{N}_4\text{O}_2$$
$$\frac{5.155 \times 10^{-4} \text{ mol C}_8\text{H}_{10}\text{N}_4\text{O}_2}{0.296 \text{ L soln}} = 1.7 \times 10^{-3} \text{ M C}_8\text{H}_{10}\text{N}_4\text{O}_2$$
  
b. 
$$42.6 \text{ g C}_6\text{H}_{12}\text{O}_6 \times \frac{1 \text{ mol C}_6\text{H}_{12}\text{O}_6}{180.0 \text{ g C}_6\text{H}_{12}\text{O}_6} = 0.237 \text{ mol C}_6\text{H}_{12}\text{O}_6$$
$$\frac{0.237 \text{ mol C}_6\text{H}_{12}\text{O}_6}{0.355 \text{ L soln}} = 0.667 \text{ M C}_6\text{H}_{12}\text{O}_6$$
- $$5.0 \text{ L blood} \times \frac{4.0 \times 10^{-3} \text{ mol C}_6\text{H}_{12}\text{O}_6}{1 \text{ L blood}} \times \frac{180.0 \text{ g C}_6\text{H}_{12}\text{O}_6}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} = 3.6 \text{ g C}_6\text{H}_{12}\text{O}_6$$

$$7. \quad 0.250 \text{ L soln} \times \frac{0.50 \text{ mol NaNO}_3}{1 \text{ L soln}} \times \frac{85.0 \text{ g NaNO}_3}{1 \text{ mol NaNO}_3} = 11 \text{ g NaNO}_3$$

Measure out 11 g NaNO<sub>3</sub> and add water up to 250 mL soln

$$8. \quad 0.3000 \text{ L soln} \times \frac{4.5 \times 10^{-4} \text{ mol O}_2}{1 \text{ L soln}} \times \frac{22.4 \text{ L O}_2}{1 \text{ mol O}_2} = 3.0 \times 10^{-3} \text{ L O}_2$$

$$3.0 \times 10^{-3} \text{ L O}_2 \times \frac{1000.0 \text{ mL}}{1 \text{ L}} = 3.0 \text{ mL O}_2$$



11. a.

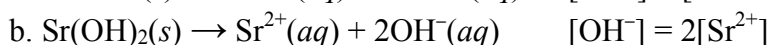
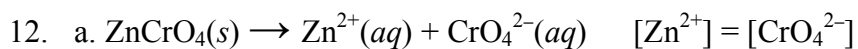
|                                 |                   |               |   |              |
|---------------------------------|-------------------|---------------|---|--------------|
| $\text{Fe}_2(\text{SO}_4)_3(s)$ |                   | $\rightarrow$ | $2\text{Fe}^{3+}(aq) + 3\text{SO}_4^{2-}(aq)$ |              |
|                                 | dissolves to form |               | 1.5 M   | ?            |
|                                 | dissolves to form |               | 1.5 M   | <b>2.3 M</b> |

$$1.5 \text{ M Fe}^{3+} \times \frac{3 \text{ M SO}_4^{2-}}{2 \text{ M Fe}^{3+}} = 2.2 \text{ or } 2.3 \text{ M SO}_4^{2-}$$

b.

|                                 |                   |               |   |       |
|---------------------------------|-------------------|---------------|---|-------|
| $\text{Fe}_2(\text{SO}_4)_3(s)$ |                   | $\rightarrow$ | $2\text{Fe}^{3+}(aq) + 3\text{SO}_4^{2-}(aq)$ |       |
|                                 | dissolves to form |               | ?   | 3.0 M |
|                                 | dissolves to form |               | <b>2.0 M</b>                                  | 3.0 M |

$$3.0 \text{ M SO}_4^{2-} \times \frac{2 \text{ M Fe}^{3+}}{3 \text{ M SO}_4^{2-}} = 2.0 \text{ M Fe}^{3+}$$



$$13. \quad 0.250 \text{ L soln} \times \frac{3.14 \times 10^{-2} \text{ mol Ca}^{2+}}{1 \text{ L soln}} \times \frac{40.1 \text{ g Ca}^{2+}}{1 \text{ mol Ca}^{2+}} = 0.31 \text{ g Ca}^{2+}$$

$$14. \quad 1.5 \text{ L soln} \times \frac{3.0 \text{ mol Na}_2\text{CO}_3}{1 \text{ L soln}} \times \frac{2 \text{ mol Na}^+}{1 \text{ mol Na}_2\text{CO}_3} \times \frac{6.02 \times 10^{23} \text{ ions Na}^+}{1 \text{ mol Na}^+}$$

$$= 5.4 \times 10^{24} \text{ ions Na}^+$$

$$15. \quad \frac{0.0050 \text{ L}}{145 \text{ drops}} \times 1 \text{ drop} = 3.45 \times 10^{-5} \text{ L}$$

$$3.45 \times 10^{-5} \text{ L soln} \times \frac{0.10 \text{ mol FeBr}_3}{1 \text{ L soln}} \times \frac{3 \text{ mol Br}^-}{1 \text{ mol FeBr}_3} \times \frac{79.9 \text{ g Br}^-}{1 \text{ mol Br}^-}$$

$$= 8.3 \times 10^{-4} \text{ g Br}^-$$

$$16. \quad 0.049 \text{ g P} \times \frac{1 \text{ mol P}}{31.0 \text{ g P}} \times \frac{1 \text{ mol H}_3\text{PO}_4}{1 \text{ mol P}} = 1.581 \times 10^{-3} \text{ mol H}_3\text{PO}_4$$

$$\frac{1.581 \times 10^{-3} \text{ mol H}_3\text{PO}_4}{0.355 \text{ L soln}} = 4.4 \times 10^{-3} \text{ M H}_3\text{PO}_4 \text{ or } 4.4 \text{ mM H}_3\text{PO}_4$$

17.

