19. $14.56 \text{ g } NaHSO_4 \times \frac{1 \text{ mol } NaHSO_4}{120.1 \text{ g } NaHSO_4} \times \frac{7 \text{ mol atoms}}{1 \text{ mol } NaHSO_4} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol atoms}}$

$= 5.11 \times 10^{23}$ 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
2. size, spacing
3. 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. $0.39 \text{ mol } SiO_2 \times \frac{22.8 \text{ cm}^3 SiO_2}{1 \text{ mol } SiO_2} = 8.9 \text{ cm}^3 SiO_2$

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

1. $17 \text{ g } H_2S \times \frac{1 \text{ mol } H_2S}{34.1 \text{ g } H_2S} \times \frac{22.4 \text{ L } H_2S}{1 \text{ mol } H_2S} = 11 \text{ L } H_2S$

2. 22.4 L C_3H_8, 3 mol C, 12.0 g C answer 1.6 g C

3. $0.200\ \text{L}\ C_2H_6O_2 \times \frac{1\ \text{mol}\ C_2H_6O_2}{0.0559\ \text{L}\ C_2H_6O_2} \times \frac{6\ \text{mol H}}{1\ \text{mol}\ C_2H_6O_2} \times \frac{6.02 \times 10^{23}\ \text{atoms H}}{1\ \text{mol H}}$

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

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

1. $1.33\ \text{g Au} \times \frac{1\ \text{cm}^3\ \text{Au}}{19.42\ \text{g Au}} = 639\ \text{cm}^3\ \text{Au}$

2. $12.7\ \text{mL Hg} \times \frac{13.534\ \text{g Hg}}{1\ \text{mL Hg}} = 172\ \text{g Hg}$

3. $\frac{46.0\ \text{g}\ C_2H_5OH}{1\ \text{mol}\ C_2H_5OH} \times \frac{1\ \text{mL}\ C_2H_5OH}{0.789\ \text{g}\ C_2H_5OH} = 58.3\ \text{mL/mol}\ C_2H_5OH$

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

1. $2.702\ \text{g/cm}^3$

2. $\frac{27.0\ \text{g Al}}{1\ \text{mol Al}} \times \frac{1\ \text{cm}^3\ \text{Al}}{2.702\ \text{g Al}} = 9.99\ \text{cm}^3\text{/mol Al}$

3. $0.74 \times \frac{9.99\ \text{cm}^3\ \text{Al}}{1\ \text{mol Al}} = 7.3945\ \text{cm}^3\text{/mol Al}$

4. $\frac{7.3945\ \text{cm}^3\ \text{Al}}{1\ \text{mol Al}} \times \frac{1\ \text{mol Al}}{6.02 \times 10^{23}\ \text{atoms Al}} = 1.228 \times 10^{-23}\ \text{cm}^3\text{/atom Al}$

5. $r^3 = \frac{1.228 \times 10^{-23}\ \text{cm}^3}{4.1888} = 2.93 \times 10^{-24}\ \text{cm}^3 \quad r = 1.43 \times 10^{-8}\ \text{cm}$

6. $1.43 \times 10^{-8}\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} \times \frac{1 \times 10^9\ \text{nm}}{1\ \text{m}} = 0.143\ \text{nm}$

3.4 Review Questions, p. 140

1. $0.250\ \text{mol}\ C_8H_{18} \times \frac{82.4\ \text{mL}\ C_8H_{18}}{1\ \text{mol}\ C_8H_{18}} = 20.6\ \text{mL}\ C_8H_{18}$

2. $2.4\ \text{L air} \times \frac{1\ \text{mol air}}{22.4\ \text{L air}} = 0.11\ \text{mol air}$

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. $2.57\ \text{L}\ P_2O_5 \times \frac{1\ \text{mol}\ P_2O_5}{22.4\ \text{L}\ P_2O_5} \times \frac{142.0\ \text{g}\ P_2O_5}{1\ \text{mol}\ P_2O_5} = 16.3\ \text{g}\ P_2O_5$

6. $\frac{0.935\ \text{g}}{525\ \text{mL}} \times \frac{22400\ \text{mL}}{1\ \text{mol}} = 39.9\ \text{g/mol (Argon)}$

7. $1400\ \text{L}\ C_2H_2 \times \frac{1\ \text{mol}\ C_2H_2}{22.4\ \text{L}\ C_2H_2} \times \frac{6.02 \times 10^{23}\ \text{molecules}\ C_2H_2}{1\ \text{mol}\ C_2H_2} = 3.8 \times 10^{25}\ \text{molecules}\ C_2H_2$

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. $9100\ \text{g}\ C_3H_8 \times \frac{1\ \text{mol}\ C_3H_8}{44.0\ \text{g}\ C_3H_8} \times \frac{22.4\ \text{L}\ C_3H_8}{1\ \text{mol}\ C_3H_8} = 4600\ \text{L}\ C_3H_8$

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. $3.84\ \text{L}\ N_2O \times \frac{1\ \text{mol}\ N_2O}{22.4\ \text{L}\ N_2O} \times \frac{2\ \text{mol N}}{1\ \text{mol}\ N_2O} \times \frac{14.0\ \text{g N}}{1\ \text{mol N}} = 4.80\ \text{g N}$

13. $27.2\ \text{L}\ N_2O_4 \times \frac{1\ \text{mol}\ N_2O_4}{22.4\ \text{L}\ N_2O_4} \times \frac{4\ \text{mol O}}{1\ \text{mol}\ N_2O_4} \times \frac{6.02 \times 10^{23}\ \text{atoms O}}{1\ \text{mol O}}$

   $= 2.92 \times 10^{24}\ \text{atoms O}$

14. $15\ \text{mL}\ C_4H_{10} \times \frac{0.601\ \text{g}\ C_4H_{10}}{1\ \text{mL}\ C_4H_{10}} = 9.0\ \text{g}\ C_4H_{10}$

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. $5.0\ cm^3\ Au \times \frac{19.42\ g\ Au}{1\ cm^3\ Au} \times \frac{1\ mol\ Au}{197.0\ g\ Au} = 0.49\ mol\ Au$

17. $15.0\ mL\ Br_2 \times \frac{3.53\ g\ Br_2}{1\ mL\ Br_2} \times \frac{1\ mol\ Br_2}{159.8\ g\ Br_2} \times \frac{6.02 \times 10^{23}\ molecules\ Br_2}{1\ mol\ Br_2}$

$= 1.99 \times 10^{23}\ molecules\ Br_2$

3.5 Composition Analysis — Determining Formulas

Warm Up, p. 142

1. 72 u
2. 29u
3. For example: more ways of creating the fragment
   For example: weaker bonds are broken to create fragment

Practice Problems — Determining Percentage Composition, p. 143

1.

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	= 32.0 g/mol	= 15.5%
		206.0 g/mol	99.9%

2.

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	= 64.0 g/mol	= 48.4%
		132.1 g/mol	100.0%

3.

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	= 64.0 g/mol	
		120.4 g/mol	
7 H_2O	(7 × 18.0 g)/mol	= 126.0 g/mol	= 51.1%
		246.4 g/mol	