

Chapter 7 – Chemical Quantities

Chapter 7: 1 – 7, 9 – 11, 13 – 18, 19 – 26, 29 - 35

Practice Problems1. What is the mass of 0.50 bushel of apples? *1 dozen apples = 2.0 kg apples = 0.20 bushel*

$$(0.50 \text{ bushel})(2.0 \text{ kg apples} / 0.20 \text{ bushel}) = 5.0 \text{ kg}$$

2. Assume a variety of apples has eight seeds in each. How many apple seeds in 14 kg of apples?

$$(14 \text{ kg apples}) \left(\frac{0.20 \text{ bushel}}{2.0 \text{ kg}} \right) \left(\frac{1 \text{ doz apples}}{0.20 \text{ bushel}} \right) \left(\frac{12 \text{ apples}}{1 \text{ dozen}} \right) \left(\frac{8 \text{ seeds}}{\text{apple}} \right) = 672 \text{ apples}$$

3. How many moles is 2.80×10^{24} atoms of silicon?

$$(2.80 \times 10^{24} \text{ atoms Si}) \left(\frac{1 \text{ mol Si}}{6.02 \times 10^{23} \text{ atoms Si}} \right) = 4.65 \text{ mol Si}$$

4. How many molecules is 0.360 mol of water?

$$(0.360 \text{ mol } H_2O) \left(\frac{6.02 \times 10^{23} \text{ molecules } H_2O}{1 \text{ mol } H_2O} \right) = 2.17 \times 10^{23} \text{ molecules } H_2O$$

5. How many atoms are there in 1.14 mol SO_3 ?

$$(1.14 \text{ mol } SO_3) \left(\frac{6.02 \times 10^{23} \text{ molecules } SO_3}{1 \text{ mol } SO_3} \right) \left(\frac{4 \text{ atoms}}{1 \text{ molecule } SO_3} \right) = 2.75 \times 10^{24} \text{ atoms}$$

6. How many moles are there in 4.65×10^{24} molecules of NO_2 ?

$$(4.65 \times 10^{24} \text{ molecules } NO_2) \left(\frac{1 \text{ mol } NO_2}{6.02 \times 10^{23} \text{ molecules } NO_2} \right) = 7.72 \text{ moles } NO_2$$

7. Find the gram molecular mass of each compound.

a. C_2H_6

$$(2 \text{ mol C}) \left(\frac{12.0 \text{ g C}}{1 \text{ mol C}} \right) = 24.0 \text{ g C}; (6 \text{ mol H}) \left(\frac{1.01 \text{ g H}}{1 \text{ mol H}} \right) = 6.06 \text{ g H}; C_2H_6 = 30.1 \text{ g}$$

b. PCl_3

$$(1 \text{ mol P}) \left(\frac{31.0 \text{ g P}}{1 \text{ mol P}} \right) = 31.0 \text{ g P}; (3 \text{ mol Cl}) \left(\frac{35.5 \text{ g Cl}}{1 \text{ mol Cl}} \right) = 106.5 \text{ g Cl}; PCl_3 = 137.5 \text{ g}$$

c. C_3H_7OH

$$(3 \text{ mol C}) \left(\frac{12.0 \text{ g C}}{1 \text{ mol C}} \right) = 36.0 \text{ g C}; (8 \text{ mol H}) \left(\frac{1.01 \text{ g H}}{1 \text{ mol H}} \right) = 8.08 \text{ g H}; (1 \text{ mol O}) \left(\frac{16.0 \text{ g O}}{1 \text{ mol O}} \right) = 16.0 \text{ g O}; C_3H_7OH = 60.1 \text{ g}$$

d. N_2O_5

$$(2 \text{ mol N}) \left(\frac{14.0 \text{ g N}}{1 \text{ mol N}} \right) = 28.0 \text{ g N}; (5 \text{ mol O}) \left(\frac{16.0 \text{ g O}}{1 \text{ mol O}} \right) = 80.0 \text{ g O}; N_2O_5 = 108 \text{ g}$$

9. Calculate the gram formula mass of each ionic compound.

a. K_2O

$$(2 \text{ mol } K) \left(\frac{39.1 \text{ g } K}{1 \text{ mol } K} \right) = 78.2 \text{ g } K; (1 \text{ mol } O) \left(\frac{16.0 \text{ g } O}{1 \text{ mol } O} \right) = 16.0 \text{ g } O; K_2O = 94.2 \text{ g}$$

b. $CaSO_4$

$$(1 \text{ mol } Ca) \left(\frac{40.1 \text{ g } Ca}{1 \text{ mol } Ca} \right) = 40.1 \text{ g } Ca; (1 \text{ mol } S) \left(\frac{32.1 \text{ g } S}{1 \text{ mol } S} \right) = 32.1 \text{ g } S; (4 \text{ mol } O) \left(\frac{16.0 \text{ g } O}{1 \text{ mol } O} \right) = 64.0 \text{ g } O; \\ CaSO_4 = 136.2 \text{ g}$$

c. CuI_2

$$(1 \text{ mol } Cu) \left(\frac{63.5 \text{ g } Cu}{1 \text{ mol } Cu} \right) = 63.5 \text{ g } Cu; (2 \text{ mol } I) \left(\frac{126.9 \text{ g } I}{1 \text{ mol } I} \right) = 253.8 \text{ g } I; CuI_2 = 317.3 \text{ g}$$

10. Find the gram formula mass of each compound.

a. barium fluoride (BaF_2)

$$(1 \text{ mol } Ba) \left(\frac{137.3 \text{ g } Ba}{1 \text{ mol } Ba} \right) = 137.3 \text{ g } Ba; (2 \text{ mol } F) \left(\frac{19.0 \text{ g } F}{1 \text{ mol } F} \right) = 38.0 \text{ g } F; BaF_2 = 175.3 \text{ g}$$

b. strontium chloride ($SrCl_2$)

$$(1 \text{ mol } Sr) \left(\frac{87.62 \text{ g } Sr}{1 \text{ mol } Sr} \right) = 87.62 \text{ g } Sr; (2 \text{ mol } Cl) \left(\frac{35.5 \text{ g } Cl}{1 \text{ mol } Cl} \right) = 71.0 \text{ g } Cl; SrCl_2 = 158.62 \text{ g}$$

c. sodium hydrogen carbonate ($NaHCO_3$)

$$(1 \text{ mol } Na) \left(\frac{23.0 \text{ g } Na}{1 \text{ mol } Na} \right) = 23.0 \text{ g } Na; (1 \text{ mol } H) \left(\frac{1.01 \text{ g } H}{1 \text{ mol } H} \right) = 1.01 \text{ g } H; (1 \text{ mol } C) \left(\frac{12.0 \text{ g } C}{1 \text{ mol } C} \right) = 12.0 \text{ g } C \\ (3 \text{ mol } O) \left(\frac{16.0 \text{ g } O}{1 \text{ mol } O} \right) = 48.0 \text{ g } O; NaHCO_3 = 84.0 \text{ g}$$

d. aluminum sulfite ($Al_2(SO_3)_3$)

$$(2 \text{ mol } Al) \left(\frac{27.0 \text{ g } Al}{1 \text{ mol } Al} \right) = 54.0 \text{ g } Al; (3 \text{ mol } S) \left(\frac{32.1 \text{ g } S}{1 \text{ mol } S} \right) = 96.3 \text{ g } S; (9 \text{ mol } O) \left(\frac{16.0 \text{ g } O}{1 \text{ mol } O} \right) = 144.0 \text{ g } O \\ Al_2(SO_3)_3 = 294 \text{ g}$$

Section Review 7.1

11. Describe the relationship between Avogadro's number and one mole of any substance.

One mole of any substance is equal to Avogadro's number, 6.02×10^{23} . The substance could represent a mole of atoms, ionic formula units, or molecules.

13. How many oxygen atoms are in a representative particle of each substance?

a. ammonium nitrate (NH_4NO_3), a fertilizer 3 oxygen atoms

b. acetylsalicylic acid ($C_8H_8O_4$), the fever-reducing compound aspirin? 4 O atoms

c. ozone (O_3), a disinfectant 3 O atoms

d. nitroglycerine ($C_3H_5(NO_3)_3$), an explosive 9 O atoms

14. How many moles is each of the following?

a. 1.50×10^{23} molecules NH_3

$$(1.50 \times 10^{23} \text{ molecules } \text{NH}_3) \left(\frac{1 \text{ mol } \text{NH}_3}{6.02 \times 10^{23} \text{ molecules}} \right) = 0.249 \text{ mol } \text{NH}_3$$

b. 1 billion (1×10^9 molecules) O_2

$$(1 \times 10^9 \text{ molecules } \text{O}_2) \left(\frac{1 \text{ mol } \text{O}_2}{6.02 \times 10^{23} \text{ molecules}} \right) = 1.66 \times 10^{-15} \text{ mol } \text{O}_2$$

c. 6.02×10^{22} molecules Br_2

$$(6.02 \times 10^{22} \text{ molecules } \text{Br}_2) \left(\frac{1 \text{ mol } \text{Br}_2}{6.02 \times 10^{23} \text{ molecules}} \right) = 0.100 \text{ mol } \text{Br}_2$$

d. 4.81×10^{24} atoms Li

$$(4.81 \times 10^{24} \text{ atoms } \text{Li}) \left(\frac{1 \text{ mol } \text{Li}}{6.02 \times 10^{23} \text{ molecules}} \right) = 7.99 \text{ mol } \text{Li}$$

15. Distinguish among gram atomic mass, gram molecular mass, and gram formula mass.

Gram atomic mass is the atomic mass of an element expressed in grams.

Gram molecular mass is the mass of a mole of a molecular element or

compound. **Gram formula mass** is the mass of a mole of an ionic compound.

Practice Problems

16. Find the mass, in grams, of each.

a. 3.32 mol K

$$(3.32 \text{ mol } M) \left(\frac{39.1 \text{ g } K}{1 \text{ mol } K} \right) = 130. \text{ g } K$$

b. 4.52×10^{-3} mol $\text{C}_{20}\text{H}_{42}$

$$(4.52 \times 10^{-3} \text{ mol } \text{C}_{20}\text{H}_{42}) \left(\frac{282 \text{ g } \text{C}_{20}\text{H}_{42}}{1 \text{ mol } \text{C}_{20}\text{H}_{42}} \right) = 1.27 \text{ g } \text{C}_{20}\text{H}_{42}$$

c. 0.0112 mol K_2CO_3

$$(0.0112 \text{ mol } \text{K}_2\text{CO}_3) \left(\frac{138.2 \text{ g } \text{K}_2\text{CO}_3}{1 \text{ mol } \text{K}_2\text{CO}_3} \right) = 1.55 \text{ g } \text{K}_2\text{CO}_3$$

17. Calculate the mass, in grams of 2.50 mol of each substance.

a. sodium sulfate (Na_2SO_4)

$$(2.50 \text{ mol } \text{Na}_2\text{SO}_4) \left(\frac{142.1 \text{ g } \text{Na}_2\text{SO}_4}{1 \text{ mol } \text{Na}_2\text{SO}_4} \right) = 355 \text{ g } \text{Na}_2\text{SO}_4$$

b. iron(II) hydroxide ($\text{Fe}(\text{OH})_2$)

$$(2.50 \text{ mol } \text{Fe}(\text{OH})_2) \left(\frac{89.8 \text{ g } \text{Fe}(\text{OH})_2}{1 \text{ mol } \text{Fe}(\text{OH})_2} \right) = 225 \text{ g } \text{Fe}(\text{OH})_2$$

18. Find the number of moles in each quantity.

a. 3.70×10^{-1} g B

$$(3.70 \times 10^{-1} \text{ g B}) \left(\frac{1 \text{ mol B}}{10.8 \text{ g B}} \right) = 0.0343 \text{ mol B}$$

b. 27.4 g TiO_2

$$(27.4 \text{ g TiO}_2) \left(\frac{1 \text{ mol TiO}_2}{60.1 \text{ g TiO}_2} \right) = 0.456 \text{ mol TiO}_2$$

c. 847 g $(\text{NH}_4)_2\text{CO}_3$

$$(847 \text{ g } (\text{NH}_4)_2\text{CO}_3) \left(\frac{1 \text{ mol } (\text{NH}_4)_2\text{CO}_3}{98.0 \text{ g } (\text{NH}_4)_2\text{CO}_3} \right) = 8.64 \text{ mol } (\text{NH}_4)_2\text{CO}_3$$

20. What is the volume at STP of these gases?

a. 3.20×10^{-3} mol CO_2

$$(3.20 \times 10^{-3} \text{ mol CO}_2) \left(\frac{22.4 \text{ L CO}_2}{1 \text{ mol CO}_2} \right) = 0.0717 \text{ L CO}_2$$

b. 0.960 mole CH_4

$$(0.960 \text{ mol CH}_4) \left(\frac{22.4 \text{ L CH}_4}{1 \text{ mol CH}_4} \right) = 21.5 \text{ L CH}_4$$

c. 3.70 mol N_2

$$(3.70 \text{ mol N}_2) \left(\frac{22.4 \text{ L N}_2}{1 \text{ mol N}_2} \right) = 82.9 \text{ L N}_2$$

21. Assuming STP, how many moles are in these volumes?

a. 67.2 L SO_2

$$(67.2 \text{ L SO}_2) \left(\frac{1 \text{ mol SO}_2}{22.4 \text{ L}} \right) = 3.00 \text{ mol SO}_2$$

b. 0.880 L He

$$(0.880 \text{ L He}) \left(\frac{1 \text{ mol He}}{22.4 \text{ L}} \right) = 0.0393 \text{ mol He}$$

c. 1.00×10^3 L C_2H_6

$$(1.00 \times 10^3 \text{ L C}_2\text{H}_6) \left(\frac{1 \text{ mol C}_2\text{H}_6}{22.4 \text{ L}} \right) = 44.6 \text{ mol C}_2\text{H}_6$$

22. A gaseous compound composed of sulfur and oxygen that is linked to the formation of acid rain has a density of 3.58 g/L at STP. What is the molar mass of this gas?

$$\left(\frac{3.58 \text{ g}}{\text{L}} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 80.2 \frac{\text{g}}{\text{mol}}$$

23. What is the density of krypton gas at STP?

$$\left(\frac{83.80 \text{ g Kr}}{\text{mol Kr}}\right) \left(\frac{1 \text{ mol Kr}}{22.4 \text{ L}}\right) = 3.74 \frac{\text{g}}{\text{L}}$$

Section Review 7.2

24. Find the mass in grams of each quantity:

a. 0.720 mol Be

$$(0.720 \text{ mol Be}) \left(\frac{9.01 \text{ g Be}}{1 \text{ mol Be}}\right) = 6.48 \text{ g Be}$$

b. 2.40 mol N₂

$$(2.40 \text{ mol N}_2) \left(\frac{28.0 \text{ g N}_2}{1 \text{ mol N}_2}\right) = 67.2 \text{ g N}_2$$

c. 0.160 mol H₂O₂

$$(0.160 \text{ mol H}_2\text{O}_2) \left(\frac{34.0 \text{ g H}_2\text{O}_2}{1 \text{ mol H}_2\text{O}_2}\right) = 5.44 \text{ g H}_2\text{O}_2$$

d. 5.08 mol Ca(NO₃)₂

$$(5.08 \text{ mol Ca(NO}_3)_2) \left(\frac{164.09 \text{ g Ca(NO}_3)_2}{1 \text{ mol Ca(NO}_3)_2}\right) = 8.34 \times 10^2 \text{ g Ca(NO}_3)_2$$

25. Calculate the following:

a. The number of molecules in 60.0 g NO₂.

$$(60.0 \text{ g NO}_2) \left(\frac{1 \text{ mol NO}_2}{46.0 \text{ g NO}_2}\right) \left(\frac{6.02 \text{ molecules NO}_2}{1 \text{ mol NO}_2}\right) = 7.85 \times 10^{23} \text{ molecules NO}_2$$

b. The volume, in liters, of 3.24×10^{22} molecules Cl₂ at STP.

$$(3.24 \times 10^{22} \text{ molecules Cl}_2) \left(\frac{1 \text{ mol Cl}_2}{6.02 \times 10^{23} \text{ molecules Cl}_2}\right) \left(\frac{22.4 \text{ L Cl}_2}{1 \text{ mol Cl}_2}\right) = 1.21 \text{ L Cl}_2$$

c. The mass, in grams, of 18.0 L CH₄ at STP.

$$(18.0 \text{ L CH}_4) \left(\frac{1 \text{ mol CH}_4}{22.4 \text{ L CH}_4}\right) \left(\frac{16.0 \text{ g CH}_4}{1 \text{ mol CH}_4}\right) = 12.9 \text{ g CH}_4$$

26. Would three balloons, each containing the same number of molecules of a different gas at STP, have the same mass or the same volume? Explain.

All three balloons would have the same volume, because equal numbers of gas particles at STP occupy the same amount of space. The masses would be different, however.

Practice Problems

29. Calculate the percent composition of the following:

a. When 9.03 g Mg combines completely with 3.48 g N to form a compound.

$$\% Mg = \left(\frac{9.03 \text{ g Mg}}{12.51 \text{ g compound}} \right) (100) = 72.2\% \quad \% N = \left(\frac{3.48 \text{ g N}}{12.51 \text{ g compound}} \right) (100) = 27.8\%$$

b. When 29.0 g Ag combines completely with 4.30 g S to form a compound.

$$\% Ag = \left(\frac{29.0 \text{ g Ag}}{33.3 \text{ g compound}} \right) (100) = 87.1\% \quad \% S = \left(\frac{4.30 \text{ g S}}{33.3 \text{ g compound}} \right) (100) = 12.9\%$$

30. When a 14.2 g sample of mercury(II) oxide is decomposed into its elements by heating, 13.2 g Hg is obtained. What is the percent composition of this compound?

$$\% Hg = \left(\frac{13.2 \text{ g Hg}}{14.2 \text{ g compound}} \right) (100) = 93\% \quad \% O = \left(\frac{1.0 \text{ g O}}{14.2 \text{ g compound}} \right) (100) = 7\%$$

31. Calculate the percent composition of these compounds.

a. ethane (C₂H₆)

$$\% C = \left(\frac{2 (12.0 \text{ g C})}{30.0 \text{ g compound}} \right) (100) = 80\% \quad \% H = \left(\frac{6 (1.01 \text{ g H})}{30.0 \text{ g compound}} \right) (100) = 20\%$$

b. sodium bisulfate (NaHSO₄)

$$\% Na = \left(\frac{23.0 \text{ g Na}}{120.1 \text{ g compound}} \right) (100) = 19.1\% \quad \% H = \left(\frac{1.01 \text{ g H}}{120.1 \text{ g compound}} \right) (100) = 0.8\%$$
$$\% S = \left(\frac{32.1 \text{ g S}}{120.1 \text{ g compound}} \right) (100) = 26.7\% \quad \% O = \left(\frac{3 (16.0 \text{ g O})}{120.1 \text{ g compound}} \right) (100) = 53.3\%$$

c. ammonium chloride (NH₄Cl)

$$\% N = \left(\frac{14.0 \text{ g N}}{53.3 \text{ g compound}} \right) (100) = 26.1\% \quad \% H = \left(\frac{4.04 \text{ g H}}{53.3 \text{ g compound}} \right) (100) = 7.6\%$$
$$\% Cl = \left(\frac{35.5 \text{ g Cl}}{53.3 \text{ g compound}} \right) (100) = 66.3\%$$

32. Calculate the percent nitrogen in these common fertilizers.

a. CO(NH₂)₂ the compound has a gram molecular weight of 60 g

$$\% N = \left(\frac{2 (14.0 \text{ g N})}{60.0 \text{ g compound}} \right) (100) = 46.7\%$$

b. NH₃ the compound has a gram molecular weight of 17.0 g

$$\% N = \left(\frac{14.0 \text{ g N}}{17.0 \text{ g compound}} \right) (100) = 82.4\%$$

c. NH₄NO₃ the compound has a gram molecular weight of 80.0 g

$$\% N = \left(\frac{2 (14.0 \text{ g N})}{80.0 \text{ g compound}} \right) (100) = 35\%$$

33. Using data from Problem 31, calculate the mass of hydrogen in each of the following.

a. 350 g C₂H₆

$$350 \text{ g C}_2\text{H}_6 \left(\frac{20 \text{ g H}}{100.0 \text{ g compound}} \right) = 70.0 \text{ g H}$$

b. 20.3 g NaHSO₄

$$20.3 \text{ g NaHSO}_4 \left(\frac{0.8 \text{ g H}}{100.0 \text{ g compound}} \right) = 0.162 \text{ g H}$$

c. 2.14 g NH₄Cl

$$2.14 \text{ g NH}_4 \left(\frac{7.6 \text{ g H}}{100.0 \text{ g compound}} \right) = 0.163 \text{ g H}$$

34. Calculate the grams of nitrogen in 125 g of each fertilizer.

a. CO(NH₂)₂

$$125 \text{ g CO(NH}_2)_2 \left(\frac{46.7 \text{ g N}}{100.0 \text{ g compound}} \right) = 58.4 \text{ g N}$$

b. NH₃

$$125 \text{ g NH}_3 \left(\frac{82.4 \text{ g N}}{100.0 \text{ g compound}} \right) = 103 \text{ g N}$$

c. NH₄NO₃

$$125 \text{ g NH}_4\text{NO}_3 \left(\frac{35.0 \text{ g N}}{100.0 \text{ g compound}} \right) = 43.8 \text{ g N}$$

35. Calculate the empirical formula of each compound.

a. 94.1% O, 5.9% H

$$94.1 \text{ g O} \left(\frac{1 \text{ mol O}}{16.0 \text{ g O}} \right) = 5.88 \text{ mol O}; \quad 5.9 \text{ g H} \left(\frac{1 \text{ mol H}}{1.01 \text{ g H}} \right) = 5.84 \text{ mol H};$$

Mole ratio: O_{5.88}H_{5.84}

Empirical formula is OH

b. 79.8% C, 20.2% H

$$79.8 \text{ g C} \left(\frac{1 \text{ mol C}}{12.0 \text{ g C}} \right) = 6.65 \text{ mol C}; \quad 20.2 \text{ g H} \left(\frac{1 \text{ mol H}}{1.01 \text{ g H}} \right) = 20 \text{ mol H};$$

Mole ratio: C_{6.65}H₂₀

Empirical formula is CH₃

c. 67.6% Hg, 10.8% S, 21.6% O

$$67.6 \text{ g Hg} \left(\frac{1 \text{ mol Hg}}{200.6 \text{ g Hg}} \right) = 0.337 \text{ mol Hg}; \quad 10.8 \text{ g S} \left(\frac{1 \text{ mol S}}{32.1 \text{ g S}} \right) = 0.336 \text{ mol S};$$

$$21.6 \text{ g O} \left(\frac{1 \text{ mol O}}{16.0 \text{ g O}} \right) = 1.35 \text{ mol O}$$

Mole ratio: Hg_{0.337}S_{0.336}O_{1.35}

Empirical formula: HgSO₄

d. 27.59% C, 1.15% H, 16.09% N, 55.17% O

$$27.59 \text{ g C} \left(\frac{1 \text{ mol C}}{12.0 \text{ g C}} \right) = 2.3 \text{ mol C}; \quad 1.15 \text{ g H} \left(\frac{1 \text{ mol H}}{1.01 \text{ g H}} \right) = 1.14 \text{ mol H};$$

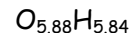
$$16.09 \text{ g N} \left(\frac{1 \text{ mol N}}{14.0 \text{ g N}} \right) = 1.15 \text{ mol N}; \quad 55.17 \text{ g O} \left(\frac{1 \text{ mol O}}{16.0 \text{ g O}} \right) = 3.44 \text{ mol O}$$

Mole ratio: C_{2.3}H_{1.14}N_{1.15}O_{3.44}

Empirical formula: C₂HNO₃

Step 1. Convert percentages into moles.

Step 2. Write the mole ratio. For 35a, it is:



Step 3. Determine the whole-number ratio, for 35a, it is nearly 1:1, so the empirical formula is OH. If you need more assistance with this, go to page 193 in the text.