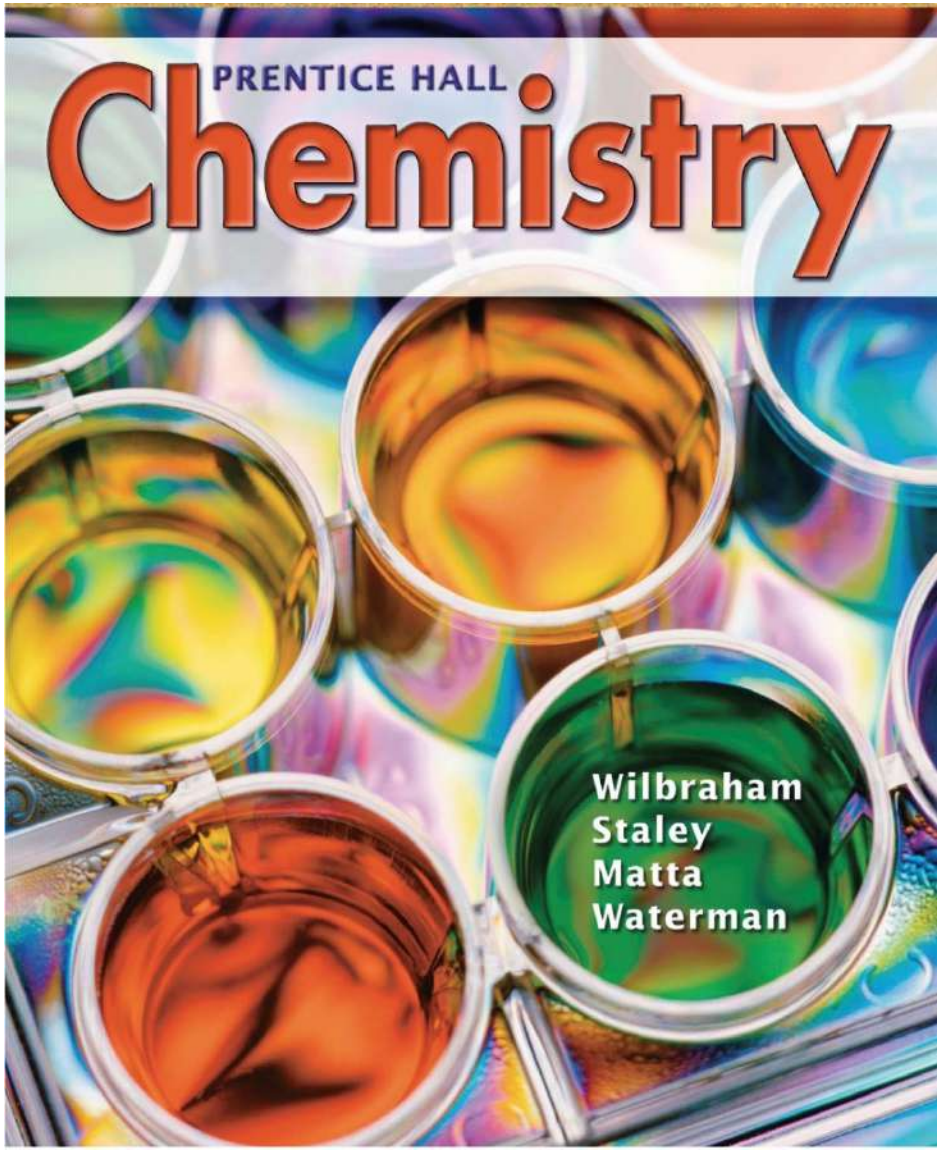
PRENTICE HALL
Chemistry
Wilbraham
Staley
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The Percent Composition of a Compound

–How do you calculate the percent by mass of an element in a compound?

–Percent Composition from Mass Data

The relative amounts of the elements in a compound are expressed as the **percent composition** or the percent by mass of each element in the compound.

$$\%\ \text{mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100\%$$

SAMPLE PROBLEM 10.9

Calculating Percent Composition from Mass Data

When a 13.60-g sample of a compound containing only magnesium and oxygen is decomposed, 5.40 g of oxygen is obtained. What is the percent composition of this compound?

SAMPLE PROBLEM 10.9

Analyze ***List the knowns and the unknowns.***

Knowns

- mass of compound = 13.60 g
- mass of oxygen = 5.40 g O
- mass of magnesium =

$$13.60\ \text{g} - 5.40\ \text{g} = 8.20\ \text{g Mg}$$

Unknowns

- percent Mg = ? % Mg
- percent O = ? % O

The percent by mass of an element in a compound is the mass of that element divided by the mass of the compound multiplied by 100%.

SAMPLE PROBLEM 10.9

Calculate ***Solve for the unknown.***

$$\%\,\text{Mg} = \frac{\text{mass of Mg}}{\text{mass of compound}} \times 100\% = \frac{8.20\ \text{g}}{13.60\ \text{g}} \times 100\%$$

$$= 60.3\%$$

$$\%\,\text{O} = \frac{\text{mass of O}}{\text{mass of compound}} \times 100\% = \frac{5.40\ \text{g}}{13.60\ \text{g}} \times 100\%$$

$$= 39.7\%$$

SAMPLE PROBLEM 10.9

Evaluate ***Does the result make sense?***

The percents of the elements add up to 100%:

$$60.3\% + 39.7\% = 100\%.$$

33. 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 the compound?

Problem Solving 10.33 *Solve Problem 33 with the help of an interactive guided tutorial.*

–Percent Composition from the Chemical Formula

$$\% \text{ mass} = \frac{\text{mass of element in 1 mol compound}}{\text{molar mass of compound}} \times 100\%$$

SAMPLE PROBLEM 10.10

Calculating Percent Composition from a Formula

Propane (C_3H_8), the fuel commonly used in gas grills, is one of the compounds obtained from petroleum. Calculate the percent composition of propane.

SAMPLE PROBLEM 10.10

Analyze ***List the knowns and the unknowns.***

Knowns

- mass of C in 1 mol C_3H_8 = 36.0 g
- mass of H in 1 mol C_3H_8 = 8.0 g
- molar mass of C_3H_8 = 44.0 g/mol

Unknowns

- percent C = ? % C
- percent H = ? % H

Calculate the percent by mass of each element by dividing the mass of that element in one mole of the compound by the molar mass of the compound and multiplying by 100%.

SAMPLE PROBLEM 10.10

Calculate ***Solve for the unknowns.***

$$\%\,\mathrm{C} = \frac{\text{mass of C}}{\text{mass of propane}} \times 100\% = \frac{36.0\,\text{g}}{44.0\,\text{g}} \times 100\% = 81.8\%$$

$$\%\,\mathrm{H} = \frac{\text{mass of H}}{\text{mass of propane}} \times 100\% = \frac{8.0\,\text{g}}{44.0\,\text{g}} \times 100\% = 18\%$$

SAMPLE PROBLEM 10.10

Evaluate ***Does the result make sense?***

The percents of the elements add up to 100% when the answers are expressed to two significant figures.

35. Calculate the percent nitrogen in these common fertilizers.

a. NH_3

b. NH_4NO_3

Problem Solving 10.34 *Solve Problem 34 with the help of an interactive guided tutorial.*

Complete SA 10.3 #s

32-35, 40, 43, 44

Starting on page 306

–Percent Composition as a Conversion Factor

You can use percent composition to calculate the number of grams of any element in a specific mass of a compound.

Propane (C_3H_8) is 81.8% carbon and 18% hydrogen. You can calculate the mass of carbon and the mass of hydrogen in an 82.0 g sample of C_3H_8.

$$82.0\ \text{g}\ \cancel{C_3H_8} \times \frac{81.8\ \text{g C}}{100\ \text{g}\ \cancel{C_3H_8}} = 67.1\ \text{g C}$$

Using the ratio 18 g H/100 g C_3H_8,you can calculate the mass of hydrogen.

$$82.0\ \text{g}\ \cancel{C_3H_8} \times \frac{18\ \text{g H}}{100\ \text{g}\ \cancel{C_3H_8}} = 15\ \text{g H}$$

The sum of the two masses equals 82 g, the sample size, to two significant figures (67.1 g C + 15 g H = 82 g C_3H_8).

What is the percent composition of $CuBr_2$?

Empirical Formulas Vs Molecular Formulas

–What does the empirical formula of a compound show?

The **empirical formula** gives the lowest whole-number ratio of the atoms of the elements in a compound.

SAMPLE PROBLEM 10.11

Determining the Empirical Formula of a Compound

A compound is analyzed and found to contain 25.9% nitrogen and 74.1% oxygen. What is the empirical formula of the compound?

SAMPLE PROBLEM 10.11

Analyze ***List the knowns and the unknown.***

Knowns

- percent of nitrogen = 25.9% N
- percent of oxygen = 74.1% O

Unknown

- Empirical formula = $N_?O_?$

The percent composition tells the ratio of the mass of nitrogen atoms to the mass of oxygen atoms in the compound. Change the ratio of masses to a ratio of moles by using conversion factors based on the molar mass of each element. Then reduce this ratio to the lowest whole-number ratio.

SAMPLE PROBLEM 10.11

Calculate ***Solve for the unknown.***

Because percent means parts per 100, you can assume that 100.0 g of the compound contains 25.9 g N and 74.1 g O. Use these values to convert to moles.

$$25.9\ \text{g N} \times \frac{1\ \text{mol N}}{14.0\ \text{g N}} = 1.85\ \text{mol N}$$

$$74.1\ \text{g O} \times \frac{1\ \text{mol O}}{16.0\ \text{g O}} = 4.63\ \text{mol O}$$

The mole ratio of nitrogen to oxygen is $N_{1.85}O_{4.63}$. But formulas must have whole-number subscripts. Divide each molar quantity by the smaller number of moles. This gives 1 mol for the element with the smaller number of moles.

$$\frac{1.85\ \text{mol N}}{1.85} = 1\ \text{mol N}; \quad \frac{4.63\ \text{mol O}}{1.85} = 2.50\ \text{mol O}$$

The result, $N_1O_{2.5}$, still has a subscript that is not a whole number. To obtain the lowest whole-number ratio, multiply each part of the ratio by the smallest whole number (in this case 2) that will convert both subscripts to whole numbers.

$$1\ \text{mol N} \times 2 = 2\ \text{mol N}$$
$$2.5\ \text{mol O} \times 2 = 5\ \text{mol O}$$

The empirical formula is N_2O_5.

SAMPLE PROBLEM 10.11

Evaluate ***Does the result make sense?***

The subscripts are whole numbers, and the percent composition of this empirical formula equals the percents given in the original problem.

37. 1,6-diaminohexane is used to make nylon. What is the empirical formula of this compound if it is 62.1% C, 13.8% H, and 24.1% N?

Problem-Solving 10.37 *Solve Problem 37 with the help of an interactive guided tutorial.*

Molecular Formulas

–How does the molecular formula of a compound compare with the empirical formula?

–The molecular formula of a compound is either the same as its experimentally determined empirical formula, or it is a simple whole-number multiple of its empirical formula.

Methanal, ethanoic acid, and glucose all have the same empirical formula—CH_2O.

Table 10.3

Comparison of Empirical and Molecular Formulas

Formula (name)	Classification of formula	Molar mass
CH	Empirical	13
C_2H_2 (ethyne)	Molecular	26 (2 × 13)
C_6H_6 (benzene)	Molecular	78 (6 × 13)
CH_2O (methanal)	Empirical and Molecular	30
$C_2H_4O_2$ (ethanoic acid)	Molecular	60 (2 × 30)
$C_6H_{12}O_6$ (glucose)	Molecular	180 (6 × 30)

SAMPLE PROBLEM 10.12

Finding the Molecular Formula of a Compound

Calculate the molecular formula of a compound whose molar mass is 60.0 g/mol and empirical formula is CH_4N.

SAMPLE PROBLEM 10.12

Analyze ***List the knowns and the unknown.***

Knowns

- empirical formula = CH_4N
- molar mass = 60.0 g/mol

Unknown

- molecular formula = ?

SAMPLE PROBLEM 10.12

Calculate ***Solve for the unknown.***

First calculate the empirical formula mass. Then divide the molar mass by the empirical formula mass to obtain a whole number. To get the molecular formula, multiply the formula subscripts by this value.

Empirical formula	efm	Molar mass/efm	Molecular formula
CH_4N	30.0	60.0/30.0 = 2	$C_2H_8N_2$

SAMPLE PROBLEM 10.12

Evaluate ***Does the result make sense?***

The molecular formula has the molar mass of the compound.

38. Find the molecular formula of ethylene glycol, which is used as antifreeze. The molar mass is 62 g/mol and the empirical formula is CH_3O.

Problem-Solving 10.38 *Solve Problem 38 with the help of an interactive guided tutorial.*

Complete SA 10.3:

#s 36, 37, 38, 39, 41, 42, 45, 46

10.3 Section Quiz.

Assess students' understanding of the concepts in Section 10.3.

Continue to:

Section Quiz

-or-

Launch:

ExamView® QuickTake

10.3 Section Quiz.

– 1. Calculate the percent by mass of carbon in cadaverine, $C_5H_{14}N_2$, a compound present in rotting meat.

- 67.4% C
- 58.8% C
- 51.7% C
- 68.2% C

10.3 Section Quiz.

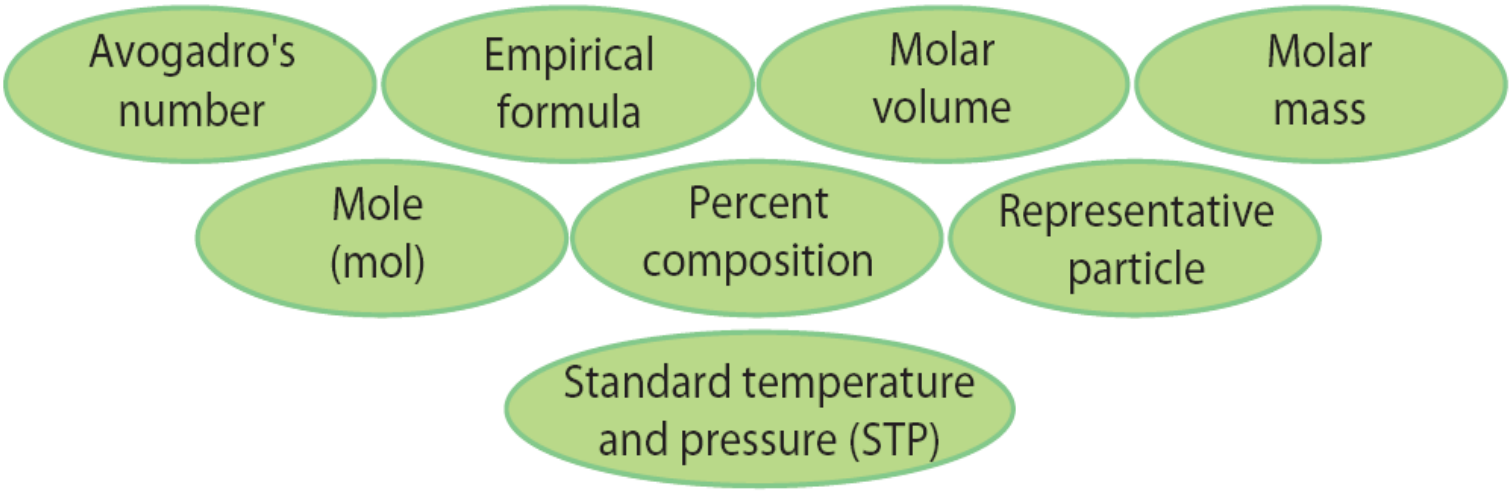
– 2. Which of the following is NOT an empirical formula?

- NO_2
- H_2N
- CH
- C_3H_6

10.3 Section Quiz.

– 3. Determine the molecular formula of a compound that contains 40.0 percent C, 6.71 percent H, and 53.29 percent O and has a molar mass of 60.05 g.

- $C_2H_4O_2$
- CH_2O
- C_2H_3O
- C_2H_4O



Concept Map 10 *Solve the Concept Map with the help of an interactive tutorial.*

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