Check Your Solution
The molar masses have been correctly determined. The calculated mass percent is reasonable and is correctly expressed to four significant digits. The order of mass percent sulfur is listed from greatest to least.

Section 6.1 Chemical Proportions and Percentage Composition

Solutions for Practice Problems

Student Edition page 264

11. Practice Problem (page 264)
A 19.6 g sample of compound A contains 16.1 g of nitrogen and 3.5 g of hydrogen. Determine the percentage composition of the compound.

What Is Required?
You need to determine the percentage composition of compound A.

What Is Given?
You know the mass of the sample compound A: 19.6 g
You know the mass of nitrogen in the sample: 16.1 g
You know the mass of hydrogen in the sample: 3.5 g

Plan Your Strategy
Calculate the mass percent of nitrogen in the sample:

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

Calculate the mass percent of hydrogen in the sample:

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

Act on Your Strategy

$$\text{mass percent of N} = \frac{\text{mass of nitrogen}}{\text{mass of compound}} \times 100\%$$

$$= \frac{16.1 \cancel{g}}{19.6 \cancel{g}} \times 100\%$$

$$= 82.1428\%$$

$$= 82\%$$

$$\text{mass percent of H} = \frac{\text{mass of hydrogen}}{\text{mass of compound}} \times 100\%$$

$$= \frac{3.5 \cancel{g}}{19.6 \cancel{g}} \times 100\%$$

$$= 17.857\%$$

$$= 18\%$$

Alternative Solution

Since there are only two elements in this compound, the mass percent of hydrogen can be calculated by subtracting the mass percent of nitrogen from 100%.

$$\text{mass percent of H} = 100\% - \text{mass percent of N}$$

$$= 100\% - 82\%$$

$$= 18\%$$

The percentage composition of compound A is 82% nitrogen and 18% hydrogen.

Check Your Solution

Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

12. Practice Problem (page 264)

A 304 g sample of compound B contains 207.9 g of chromium and 96.1 g of oxygen. Determine the percentage composition.

What Is Required?

You need to determine the percentage composition of compound B.

What Is Given?

You know the mass of the sample compound B: 304 g
You know the mass of chromium in the sample: 207.9 g
You know the mass of oxygen in the sample: 96.1 g

Plan Your Strategy

Calculate the mass percent of chromium in the sample:

$$\frac{\text{mass of chromium}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the sample:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy

$$\text{mass percent Cr} = \frac{\text{mass of chromium}}{\text{mass of sample}} \times 100\%$$

$$= \frac{207.9 \cancel{\text{g}}}{304 \cancel{\text{g}}} \times 100\%$$

$$= 68.388\%$$

$$= 68.4\%$$

$$\text{mass percent O} = \frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{96.1 \cancel{\text{g}}}{304 \cancel{\text{g}}} \times 100\%$$

$$= 31.6118\%$$

$$= 31.6\%$$

Alternative Solution

Since there are only two elements in this compound, the mass percent of oxygen can be calculated by subtracting the mass percent of chromium from 100%.

$$\text{mass percent of O} = 100\% - \text{mass percent of Cr}$$

$$= 100\% - 68.4\%$$

$$= 31.6\%$$

The percentage composition of compound B is 68.4% chromium and 31.6% oxygen.

Check Your Solution

Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

13. Practice Problem (page 264)

A 60.0 mg sample of compound C contains 24.0 mg of carbon, 4.0 mg of hydrogen, and 32.0 mg of oxygen. Determine the percentage composition.

What Is Required?

You need to determine the percentage composition of compound C.

What Is Given?

You know the mass of the sample compound C: 60.0 mg
You know the mass of carbon in the sample: 24.0 mg
You know the mass of hydrogen in the sample: 4.0 mg
You know the mass of oxygen in the sample: 32.0 mg

Plan Your Strategy

Calculate the mass percent of carbon in the sample:

$$\frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of hydrogen in the sample:

$$\frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the sample:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy

$$\text{mass percent of C} = \frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

$$= \frac{24.0 \cancel{\text{ mg}}}{60.0 \cancel{\text{ mg}}} \times 100\%$$

$$= 40\%$$

$$\text{mass percent of H} = \frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{4.0 \cancel{\text{ mg}}}{60.0 \cancel{\text{ mg}}} \times 100\%$$

$$= 6.6666\%$$

$$= 6.7\%$$

$$\text{mass percent of O} = \frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{32.0 \cancel{\text{mg}}}{60.0 \cancel{\text{mg}}} \times 100\%$$

$$= 53.333\%$$

$$= 53.3\%$$

Alternative Solution

The mass percent of oxygen can be calculated by subtracting the sum of the mass percentages of carbon and hydrogen from 100%.

$$\text{mass percent of O} = 100\% - (\text{mass percent of C} + \text{mass percent of H})$$

$$= 100\% - (40\% + 6.7\%)$$

$$= 100\% - 46.7\%$$

$$= 53.3\%$$

The percentage composition of compound C is 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen.

Check Your Solution

Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

14. Practice Problem (page 264)

A 15 g sample of compound D contains 7.22 g of nickel, 2.53 g of phosphorus, and 5.25 g of oxygen. Determine the percentage composition.

What Is Required?

You need to determine the percentage composition of compound D.

What Is Given?

You know the mass of the sample compound D: 15 g
You know the mass of nickel in the sample: 7.22 g
You know the mass of phosphorus in the sample: 2.53 g
You know the mass of oxygen in the sample: 5.25 g

Plan Your Strategy

Calculate the mass percent of nickel in the sample:

$$\frac{\text{mass of nickel}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of phosphorus in the sample:

$$\frac{\text{mass of phosphorus}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the sample:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy

$$\text{mass percent of Ni} = \frac{\text{mass of nickel}}{\text{mass of sample}} \times 100\%$$

$$= \frac{7.22 \cancel{\text{g}}}{15 \cancel{\text{g}}} \times 100\%$$

$$= 48.1333\%$$

$$= 48\%$$

$$\text{mass percent of P} = \frac{\text{mass of phosphorus}}{\text{mass of sample}} \times 100\%$$

$$= \frac{2.53 \cancel{\text{g}}}{15 \cancel{\text{g}}} \times 100\%$$

$$= 16.8666\%$$

$$= 17\%$$

$$\text{mass percent of O} = \frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{5.25 \cancel{\text{g}}}{15 \cancel{\text{g}}} \times 100\%$$

$$= 35\%$$

Alternative Solution

The mass percent of oxygen can be calculated by subtracting the sum of the mass percentages of nickel and phosphorus from 100%.

$$\text{mass percent of O} = 100\% - (\text{mass percent of Ni} + \text{mass percent of P})$$

$$= 100\% - (48\% + 17\%)$$

$$= 100\% - 65\%$$

$$= 35\%$$

The percentage composition of compound D is 48% nickel, 17% phosphorus, and 35% oxygen.

Check Your Solution
Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

15. Practice Problem (page 264)
A sample of an unknown compound contains 84.05 g of carbon, 5.00 g of hydrogen, 42.02 g of nitrogen, and 96.08 g of oxygen. Determine the percentage composition of the compound.

What Is Required?
You need to calculate the percentage composition of an unknown own compound.

What Is Given?
You know the mass of carbon in the sample: 84.05 g
You know the mass of hydrogen in the sample: 5.00 g
You know the mass of nitrogen in the sample: 42.02 g
You know the mass of oxygen in the sample: 96.08 g

Plan Your Strategy
Add the mass of each element together to determine the total mass of the unknown compound.
Calculate the mass percent of carbon in the sample:

$$\frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of hydrogen in the sample:

$$\frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of nitrogen in the sample:

$$\frac{\text{mass of nitrogen}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the sample:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy
Mass, m, of unknown compound:

$$m = 84.05\text{ g C} + 5.00\text{ g H} + 42.02\text{ g N} + 96.08\text{ g O}$$
$$= 227.15\text{ g}$$

$$\text{mass percent of C} = \frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$
$$= \frac{84.05 \cancel{g}}{227.15 \cancel{g}} \times 100\%$$
$$= 37.001\%$$
$$= 37.0\%$$

$$\text{mass percent of H} = \frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$
$$= \frac{5.0 \cancel{g}}{227.15 \cancel{g}} \times 100\%$$
$$= 2.201\%$$
$$= 2.20\%$$

$$\text{mass percent of N} = \frac{\text{mass of nitrogen}}{\text{mass of sample}} \times 100\%$$
$$= \frac{42.02 \cancel{g}}{227.15 \cancel{g}} \times 100\%$$
$$= 18.498\%$$
$$= 18.5\%$$

$$\text{mass percent of O} = \frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$
$$= \frac{96.08 \cancel{g}}{227.15 \cancel{g}} \times 100\%$$
$$= 42.298\%$$
$$= 42.3\%$$

Alternative Solution

The mass percent of oxygen can be calculated by subtracting the sum of the mass percentages of carbon, hydrogen, and nitrogen from 100%.

$$\begin{aligned}\text{mass percent of O} &= 100\% - (\text{mass percent of C} + \text{mass percent of H} + \text{mass percent of N}) \\ &= 100\% - (37\% + 2.20\% + 18.5\%) \\ &= 100\% - 57.7\% \\ &= 42.3\%\end{aligned}$$

The percentage composition of the unknown compound is 37.0% carbon, 2.20% hydrogen, 18.5% nitrogen and 42.3% oxygen.

Check Your Solution
Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

16. Practice Problem (page 264)
What is the percentage composition of a compound with a mass of 48.72 g, if it contains 32.69 g of zinc and 16.03 g of sulfur?

What Is Required?
You need to determine the percentage composition of a compound.

What Is Given?
You know the mass of the sample compound: 48.72 g
You know the mass of zinc in the sample: 32.69 g
You know the mass of sulfur in the sample: 16.03 g

Plan Your Strategy
Calculate the mass percent of zinc in the compound:

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

Calculate the mass percent of sulfur in the compound:

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

Act on Your Strategy

$$\begin{aligned}\text{mass percent of Zn} &= \frac{\text{mass of zinc}}{\text{mass of compound}} \times 100\% \\ &= \frac{32.69\ \cancel{g}}{48.72\ \cancel{g}} \times 100\% \\ &= 67.0977\% \\ &= 67.1\%\end{aligned}$$

$$\text{mass percent of S} = \frac{\text{mass of sulfur}}{\text{mass of compound}} \times 100\%$$
$$= \frac{16.03 \cancel{\text{g}}}{48.72 \cancel{\text{g}}} \times 100\%$$
$$= 32.902\%$$
$$= 32.90\%$$

Alternative Solution
Since there are only two elements in this compound, the mass percent of sulfur can be calculated by subtracting the mass percent of zinc from 100%.

$$\text{mass percent of S} = 100\% - \text{mass percent of Zn}$$
$$= 100\% - 67.10\%$$
$$= 32.90\%$$

The percentage composition of the compound is 67.10% zinc and 32.90% sulfur.

Check Your Solution
Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

17. Practice Problem (page 264)
The percentage composition of a compound is 79.9% copper and 20.1% sulfur. The mass of a sample of the compound is 160.0 g. What are the masses of the copper and sulfur in the sample?

What Is Required?
You need to calculate the masses of copper and sulfur in a compound.

What Is Given?
You know the mass of the compound: 160.0 g
You know the mass percent copper in the compound: 79.9%
You know the mass percent sulfur in the compound: 20.1%

Plan Your Strategy
mass of copper = percentage copper × mass of compound
mass of sulfur = percentage sulfur × mass of compound

Act on Your Strategy

$$\text{mass of copper} = \text{percentage copper} \times \text{mass of compound}$$

$$= \frac{79.9}{100} \times 160.0 \text{ g}$$

$$= 127.84 \text{ g}$$

$$= 128 \text{ g}$$

$$\text{mass of sulfur} = \text{percentage sulfur} \times \text{mass of compound}$$

$$= \frac{20.1}{100} \times 160.0 \text{ g}$$

$$= 32.16 \text{ g}$$

$$= 32.2 \text{ g}$$

Alternative Solution

Since there are only two elements in this compound, the mass of sulfur can be calculated by subtracting the mass of copper from the mass of the compound.

$$\text{mass of S} = \text{mass of compound} - \text{mass of Cu}$$

$$= 160.0 \text{ g} - 127.84 \text{ g}$$

$$= 32.16 \text{ g}$$

$$= 32.2 \text{ g}$$

The compound contains 128 g of copper and 32.0 g of sulfur.

Check Your Solution

The sum of the mass of each element totals the mass of the compound (rounded values). The number of significant digits matches that in the given data.

18. Practice Problem (page 264)

A chemist analyzed a sample of a compound that was known to contain potassium, manganese, and oxygen. She obtained the following results:
Total mass of sample = 316.08 g
Mass of potassium = 78.20 g
Mass of manganese = 109.88 g
Determine the percentage composition of the compound.

What Is Required?

You need to determine the percentage composition of a compound.

What Is Given?
You know the mass of the sample compound: 316.08 g
You know the mass of potassium, K, in the compound: 78.20 g
You know the mass of manganese, Mn, in the compound: 109.88 g

Plan Your Strategy
Determine the mass of oxygen in the sample by subtracting the sum of the masses of potassium and manganese from the mass of the sample.
Calculate the mass percent of potassium in the compound:

$$\frac{\text{mass of potassium}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of manganese in the compound:

$$\frac{\text{mass of manganese}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the compound:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy

$$\begin{aligned}\text{mass of O} &= \text{mass of sample} - (\text{mass of K} + \text{mass of Mn}) \\ &= 316.08\text{ g} - (78.20\text{ g} + 109.88\text{ g}) \\ &= 128.00\text{ g}\end{aligned}$$

$$\begin{aligned}\text{mass percent of K} &= \frac{\text{mass of potassium}}{\text{mass of sample}} \times 100\% \\ &= \frac{78.20\ \cancel{\text{g}}}{316.08\ \cancel{\text{g}}} \times 100\% \\ &= 24.705\% \\ &= 24.74\%\end{aligned}$$

$$\begin{aligned}\text{mass percent of Mn} &= \frac{\text{mass of manganese}}{\text{mass of sample}} \times 100\% \\ &= \frac{109.88\ \cancel{\text{g}}}{316.08\ \cancel{\text{g}}} \times 100\% \\ &= 34.76335\% \\ &= 34.763\% \\ &= 34.76\%\end{aligned}$$

$$\text{mass percent of O} = \frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{128.00 \cancel{g}}{316.08 \cancel{g}} \times 100\%$$

$$= 40.4960\%$$

$$= 40.96\%$$

$$= 40.50\%$$

Alternative Solution

The mass percent of oxygen can be calculated by subtracting the sum of the mass percentages of potassium and manganese from 100%.

$$\text{mass percent of O} = 100\% - (\text{mass percent of K} + \text{mass percent of Mn})$$

$$= 100\% - (24.741\% + 34.763\%)$$

$$= 100\% - 59.504\%$$

$$= 40.496\%$$

$$= 40.5\%$$

Check Your Solution

Addition of the mass percent of each element totals 100% and the percentage composition shows the correct number of significant digits.

19. Practice Problem (page 264)

A volatile chemical was removed from a crime scene. Analysis of a 35.20 mg sample of the chemical showed that it contained 3.56 mg of carbon and 0.28 mg of hydrogen. Later, investigators learned that the chemical was chloroform, $CHCl_3(\ell)$. What is the percentage composition of chloroform?

What Is Required?

You need to determine the mass percent of carbon and hydrogen in a compound and determine the percentage composition of chloroform.

What Is Given?

You know the mass of the sample compound: 35.20 mg
You know the mass of carbon in the sample: 3.56 mg
You know the mass of hydrogen in the sample: 0.28 mg

Plan Your Strategy

Calculate the mass percent of carbon in the sample:

$$\frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of hydrogen in the sample:

$$\frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of chlorine in chloroform by subtracting the sum of the mass percentages of carbon and hydrogen from 100%.

Act on Your Strategy

$$\text{mass percent of C} = \frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

$$= \frac{3.56 \cancel{\text{mg}}}{35.20 \cancel{\text{mg}}} \times 100\%$$

$$= 10.1136\%$$

$$= 10.1\%$$

$$\text{mass percent of H} = \frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

$$= \frac{0.28 \cancel{\text{mg}}}{35.20 \cancel{\text{mg}}} \times 100\%$$

$$= 0.79545\%$$

$$= 0.80\%$$

$$\text{mass percent of Cl} = 100\% - (\text{mass percent of C} + \text{mass percent of H})$$

$$= 100\% - (10.1\% + 0.80)$$

$$= 100\% - 10.9\%$$

$$= 89.1\%$$

The percent composition of chloroform is 10.1% carbon, 0.80% hydrogen, and 89.1% chlorine.

Check Your Solution

Addition of the mass percent of each element in chloroform totals 100.0% (rounded value) and the percentage composition shows the correct number of significant digits.

20. Practice Problem (page 264)

A 68.2 g sample of an unknown alcohol was tested by a student and found to contain 44.2 g of carbon, 9.3 g of hydrogen, and 14.7 g of oxygen. The student concluded that the unknown alcohol was ethanol, $C_2H_5OH(\ell)$, which contains 52.1% carbon, 13.2% hydrogen, and 34.7% oxygen. Was the student correct? Explain, using percentage composition calculations.

What Is Required?

You need to compare the percentage composition of an unknown alcohol to the percentage composition of ethanol.

What Is Given?

You know the mass of the sample of alcohol: 68.2 g
You know the mass of carbon in the alcohol sample: 44.2 g
You know the mass of hydrogen in the alcohol sample: 9.3 g
You know the mass of oxygen in the alcohol sample: 14.7 g
You know the percentage composition of ethanol: 52.1% carbon, 13.2% hydrogen, and 34.7% oxygen

Plan Your Strategy

Calculate the mass percent of carbon in the sample:

$$\frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of hydrogen in the sample:

$$\frac{\text{mass of hydrogen}}{\text{mass of sample}} \times 100\%$$

Calculate the mass percent of oxygen in the sample:

$$\frac{\text{mass of oxygen}}{\text{mass of sample}} \times 100\%$$

Act on Your Strategy

$$\begin{aligned}\text{mass percent of C} &= \frac{\text{mass of carbon}}{\text{mass of sample}} \times 100\% \\ &= \frac{44.2 \cancel{\text{g}}}{68.2 \cancel{\text{g}}} \times 100\% \\ &= 64.809\% \\ &= 64.8\%\end{aligned}$$