Chapter 3

1. An 18-g sample of element A combines completely with a 4-g sample of element B to form the compound AB. What is the mass of the compound formed?

$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}}$

$\text{Mass}_{A} + \text{Mass}_{B} = \text{Mass}_{AB}$

$\text{Mass}_{AB} = 18\text{ g} + 4\text{ g} = 22\text{ g}$

2. A substance breaks down into three component elements when it is heated. The mass of each component element is listed in the table below. What was the mass of the substance before it was heated?

Component	Mass (g)
A	39.10
B	54.94
C	64.00

$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}} = 39.10 + 54.94 + 64.00 = 158.04\text{ g}$

3. Silver iodide powder has been used as an antiseptic and as an agent to seed clouds for rain. Silver iodide is 45.9% silver by mass. If you separate a 50-g sample of silver iodide into its elements, silver and iodine, how much silver would you have?

From the conservation of mass, the mass of silver recovered is equal to the mass of silver in the initial silver iodide sample. The amount of silver recovered would be $50.0\text{ g} \times 45.9\% = 50.0 \times 0.459 = 22.95\text{ g} = 23\text{ g}$.

4. If 5 g of element A combines with 16 g of element B to form compound AB, how many grams of B are needed to form compound AB_2? How many grams of B are needed to form AB_3?

Compound AB_2 contains twice as much element B as does compound AB. Therefore, $2 \times 6\text{ g} = 32\text{ g}$. There is 32 g of B in AB_2. Compound AB_3 contains three times as much element B as does compound AB. Therefore, $3 \times 16\text{ g} = 48\text{ g}$. There is 48 g of B in AB_3.

5. During a chemical reaction, 2.445 g of carbon reacts with 3.257 g of oxygen to form carbon monoxide gas. How many grams of carbon monoxide are formed in this reaction?

$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}}$

$\text{Mass}_{\text{carbon}} + \text{Mass}_{\text{oxygen}} = \text{Mass}_{\text{carbon monoxide}}$

$2.445\text{ g} + 3.257\text{ g} = 5.702\text{ g}$

6. Ibuprofen has the chemical formula $C_{13}H_{18}O_2$. It is 75.69% carbon, 8.80% hydrogen, and 15.51% oxygen. How many mg of carbon does a 200-mg tablet of ibuprofen contain?

$$\text{Mass percentage of an element (\%)} = \frac{\text{Mass of element}}{\text{Mass of compound}} \times 100\%$$

$$\text{Mass percentage}_{\text{carbon}} = \frac{\text{Mass}_{\text{carbon}}}{\text{Mass}_{\text{compound}}} \times 100\%$$

$$75.69\%\text{ carbon} = \frac{\text{Mass}_{\text{carbon}}}{200\text{ mg}} \times 100\%$$

$$75.69\%\text{ carbon} \times \frac{200\text{ mg}}{100\%} = \text{Mass}_{\text{carbon}}$$

$\text{Mass}_{\text{carbon}}$ in the tablet $= 151.38\text{ mg}$

7. During a chemical reaction, 4.032 g of hydrogen combined with oxygen to form 36.032 g of water. How many grams of oxygen reacted?

$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}}$

$\text{Mass}_{\text{hydrogen}} + \text{Mass}_{\text{oxygen}} = \text{Mass}_{\text{water}}$

$4.032\text{ g} + \text{Mass}_{\text{oxygen}} = 36.032\text{ g}$

$\text{Mass}_{\text{oxygen}} = 36.032\text{ g} - 4.032\text{ g} = 32\text{ g}$

8. Nitrogen and oxygen combine to form different compounds, as shown below.

Compound	Chemical Formula	Mass N/1 g O
Nitric oxide	NO	1.76 g
Nitrogen dioxide	NO_2	0.88 g
Nitrous oxide	NO_4	0.44 g

What is the ratio of the masses of nitrogen in each of the following?

$NO_2/NO_4 =$ _____

$\frac{0.88\ g}{0.44\ g} = 2$

$NO/NO_4 =$ _____

$\frac{1.76\ g}{0.44\ g} = 4$

$NO/NO_2 =$ _____

$\frac{1.76\ g}{0.88\ g} = 2$

9. Carbon and oxygen combine to form carbon monoxide (CO) and carbon dioxide (CO_2). The masses of oxygen that combine with 12 g of carbon to form these two compounds are 16 g and 32 g, respectively. What is the ratio of the masses of oxygen in CO_2/CO?

$$\frac{\text{Mass ratio}_{\text{carbon dioxide}}}{\text{Mass ratio}_{\text{carbon monoxide}}} = \frac{32\ g}{16\ g} = 2$$

10. Phosphorus and chlorine combine to form two different compounds. In one compound, 3.88 g of phosphorus combines with 13.28 g of chlorine. In the other compound, 1.32 g of phosphorus combines with 7.56 g of chlorine. Do these data support the law of multiple proportions? Show your work.

First, find the mass ratio for each compound.

Compound I: $\frac{\text{Mass}_P}{\text{Mass}_{Cl}} = \frac{3.88\ g}{13.28\ g} = 0.292$

Compound II: $\frac{\text{Mass}_P}{\text{Mass}_{Cl}} = \frac{1.32\ g}{7.56\ g} = 0.175$

Then, compare the two mass ratios.

$$\frac{\text{Mass ratio}_{\text{compound I}}}{\text{Mass ratio}_{\text{compound II}}} = \frac{0.292}{0.175} = 1.67$$

These data are not consistent with the law of multiple proportions. The law of multiple proportions states that the different masses of Y that combine with a fixed mass of X can be expressed as a ratio of small whole numbers, and 1.67 is not a whole number.

11. Fluorine and xenon combine to form two different compounds. In one compound, 0.853 g of fluorine combines with 1.472 g of xenon. In the other compound, 0.624 g of fluorine combines with 2.16 g of xenon. Do these data support the law of multiple proportions? Show your work.

First, find the mass ratio for each compound.

Compound I: $\frac{\text{Mass}_F}{\text{Mass}_{Xe}} = \frac{0.853\ g}{1.472\ g} = 0.579$

Compound II: $\frac{\text{Mass}_F}{\text{Mass}_{Xe}} = \frac{0.624\ g}{2.16\ g} = 0.289$

Then, compare the two mass ratios.

$$\frac{\text{Mass ratio}_{\text{compound I}}}{\text{Mass ratio}_{\text{compound II}}} = \frac{0.579}{0.289} = 2.00$$

These data are consistent with the law of multiple proportions. The law of multiple proportions states that the different masses of Y that combine with a fixed mass of X can be expressed as a ratio of small whole numbers, and 2 is a whole number.

12. Ferric chloride is 34.4% iron and 65.6% chlorine by mass. A chemist analyzes three compounds that contain iron and chlorine. Her results are summarized in the data table below. Which of these compounds is likely to be ferric chloride? Explain your answer.

Compound	Mass of the Sample (g)	Mass of Fe (g)	Mass of Cl (g)
I	25	9.3	15.7
II	25	8.6	16.4
III	27	9.3	17.7

First, find the percent of iron by mass in each compound.

$$\text{Mass percentage}_{\text{iron}} = \frac{\text{Mass}_{\text{iron}}}{\text{Mass}_{\text{compound I}}} \times 100\%$$

$$= \frac{9.3\text{ g}}{25\text{ g}} \times 100\% =$$

37.2%

$$\text{Mass percentage}_{\text{iron}} = \frac{\text{Mass}_{\text{iron}}}{\text{Mass}_{\text{compound II}}} \times 100\%$$

$$= \frac{8.6\text{ g}}{25\text{ g}} \times 100\% = 34.4\%$$

$$\text{Mass percentage}_{\text{iron}} = \frac{\text{Mass}_{\text{iron}}}{\text{Mass}_{\text{compound III}}} \times 100\%$$

$$= \frac{9.3\text{ g}}{27\text{ g}} \times 100\% = 34.4\%$$

Then, find the percent of chlorine by mass in each compound.

$$\text{Mass percentage}_{\text{chlorine}} = \frac{\text{Mass}_{\text{chlorine}}}{\text{Mass}_{\text{compound I}}} \times 100\%$$

$$= \frac{15.7\text{ g}}{25\text{ g}} \times 100\% = 62.8\%$$

$$\text{Mass percentage}_{\text{chlorine}} = \frac{\text{Mass}_{\text{chlorine}}}{\text{Mass}_{\text{compound II}}} \times 100\%$$

$$= \frac{16.4\text{ g}}{25\text{ g}} \times 100\% = 65.6\%$$

$$\text{Mass percentage}_{\text{chlorine}} = \frac{\text{Mass}_{\text{chlorine}}}{\text{Mass}_{\text{compound III}}} \times 100\%$$

$$= \frac{17.7\text{ g}}{27\text{ g}} \times 100\% = 65.6\%$$

Compounds II and III have the same composition as ferric chloride.

13. The chemical formula for baking soda is $NaHCO_3$. A 168.02-g sample of baking soda contains 45.98 g of sodium, 2.02 g of hydrogen, 24.02 g of carbon, and 96 g of oxygen. What is the mass percentage of each element in baking soda?

$$\text{Mass percentage}_{\text{sodium}} = \frac{\text{Mass}_{\text{sodium}}}{\text{Mass}_{\text{baking soda}}} \times 100\%$$

$$= \frac{45.98\text{ g}}{168.02\text{ g}} \times 100\% = 27.36\%$$

$$\text{Mass percentage}_{\text{hydrogen}} = \frac{\text{Mass}_{\text{hydrogen}}}{\text{Mass}_{\text{baking soda}}} \times 100\%$$

$$= \frac{2.02\text{ g}}{168.02\text{ g}} \times 100\% = 1.20\%$$

$$\text{Mass percentage}_{\text{carbon}} = \frac{\text{Mass}_{\text{carbon}}}{\text{Mass}_{\text{baking soda}}} \times 100\%$$

$$= \frac{24.02\text{ g}}{168.02\text{ g}} \times 100\% = 14.30\%$$

$$\text{Mass percentage}_{\text{oxygen}} = \frac{\text{Mass}_{\text{oxygen}}}{\text{Mass}_{\text{baking soda}}} \times 100\%$$

$$= \frac{96\text{ g}}{168.02\text{ g}} \times 100\% = 57.14\%$$

14. The chemical formula for chalk is $CaCO_3$. A100-g sample of chalk contains 40 g of calcium, 12 g of carbon, and 48 g of oxygen. What is the mass percentage of each element in chalk? What would be the mass of calcium in 200 g of chalk?

$$\text{Mass percentage}_{\text{calcium}} = \frac{\text{Mass}_{\text{calcium}}}{\text{Mass}_{\text{chalk}}} \times 100\%$$

$$= \frac{40\text{ g}}{100\text{ g}} \times 100\% = 40\%$$

$$\text{Mass percentage}_{\text{carbon}} = \frac{\text{Mass}_{\text{carbon}}}{\text{Mass}_{\text{chalk}}} \times 100\%$$

$$= \frac{12\text{ g}}{100\text{ g}} \times 100\% = 12\%$$

$$\text{Mass percentage}_{\text{oxygen}} = \frac{\text{Mass}_{\text{oxygen}}}{\text{Mass}_{\text{chalk}}} \times 100\%$$

$$= \frac{48\text{ g}}{100\text{ g}} \times 100\% = 48\%$$

$$\text{Mass percentage}_{\text{calcium}} = \frac{\text{Mass}_{\text{calcium}}}{\text{Mass}_{\text{chalk}}} \times 100\%$$

$$\text{Mass}_{\text{calcium}} = \frac{(40\%)(200\text{ g})}{100\%} = 80\text{ g}$$

15. A 17-g sample of ammonia, NH_3, contains 3 g of hydrogen. What percentage of ammonia is hydrogen? How many grams of nitrogen does the sample contain?

$$\text{Mass percentage}_{\text{hydrogen}} = \frac{\text{Mass}_{\text{hydrogen}}}{\text{Mass}_{\text{ammonia}}} \times 100\%$$

$= \frac{3\text{ g}}{17\text{ g}} \times 100\% = 18\%$

$\text{Mass}_{\text{reactants}} = \text{Mass}_{\text{products}}$

$\text{Mass}_{\text{nitrogen}} + \text{Mass}_{\text{hydrogen}} = \text{Mass}_{\text{ammonia}}$

$\text{Mass}_{\text{nitrogen}} = \text{Mass}_{\text{ammonia}} - \text{Mass}_{\text{hydrogen}}$

$14\text{ g} = 17\text{ g} - 3\text{ g}$

Chapter 4

1. Use the periodic table to complete the following table.

Atomic number = number of protons = number of electrons

Element	Atomic Number	Protons	Electrons
a. Li	3	3	3
b. Fr	87	87	87
c. Np	93	93	93
d. Hg	80	80	80
e. Tl	81	81	81
f. Re	75	75	75
g. B	5	5	5

2. Give the number of protons, electrons, and neutrons in each of the following atoms.

Atomic number = number of protons = number of electrons

Number of neutrons = mass number − atomic number

a. $^{108}_{47}\text{Au}$

47 protons, 47 electrons, 61 neutrons
(108 − 47 = 61)

b. $^{40}_{20}\text{Ca}$

20 protons, 20 electrons, 20 neutrons
(40 − 20 = 20)

c. $^{23}_{11}\text{Na}$

11 protons, 11 electrons, 12 neutrons
(23 − 11 = 12)

3. Name each isotope, and write it in symbolic notation.

a. atomic number 26; mass number 56

iron-56; $^{56}_{26}\text{Fe}$

b. atomic number 29; mass number 64

copper-64; $^{64}_{29}\text{Cu}$

c. atomic number 17; mass number 37

chlorine-37; $^{37}_{17}\text{Cl}$

4. How many protons, electrons, and neutrons are in each of the following isotopes?

Atomic number = number of protons − number of electrons

Number of neutrons = mass number − atomic number

a. uranium-235

92 protons, 92 electrons, 143 neutrons
(235 − 92 = 143)

b. hydrogen-3

1 proton, 1 electron, 2 neutrons
(3 − 1 = 2)

c. silicon-29

14 protons, 14 electrons, 15 neutrons
(29 − 14 = 15)