Math Diversion Problem 905

P. Reany

November 15, 2025

> Don't ever take a fence down until you know
> the reason it was put up.
> — Chesterton

```
Source:  http://www.uh.edu/~chem1p/c3/C3F99.pdf
 Title:  Mystery Carbohydrate (Vit C)
  Presenter: Patrick
```

Definitions:

FW = Formula weight = molar mass
ppt = precipitate
At wt = atomic weight

1 Problem

Vitamin C (M= 176.12 g·mol^{-1}) contains C, H and O. A 1.000 g sample was placed in a combustion apparatus [and the following are facts about the masses of the products, derived by 'weighing'[1]]:

Mass of CO_2 is 1.50 grams.
Mass of H_2O is 0.41 grams.

What is the molecular formula of vitamin C?

2 Solution

Step 1.

We'll begin with an unbalanced equation to work with

$$C_xH_yO_z + O_2 \to CO_2 + H_2O\,. \tag{1}$$

[1]Or, the mass can be calculated by use of knowledge of moles and molar mass of the compound.

Next, by inspection we can balance this equation on elements C and H in terms of unknowns x and y, leaving a to be determined by balancing on element O:

$$\mathrm{C}_x\mathrm{H}_y\mathrm{O}_z + a\mathrm{O}_2 \to x\mathrm{CO}_2 + \frac{y}{2}\mathrm{H}_2\mathrm{O}\,. \tag{2}$$

yielding:

$$z + 2a = 2x + y/2\,, \tag{3}$$

which, when solved for a, yields

$$a = x + y/4 - z/2\,. \tag{4}$$

Step 2. Once again, a diagram.

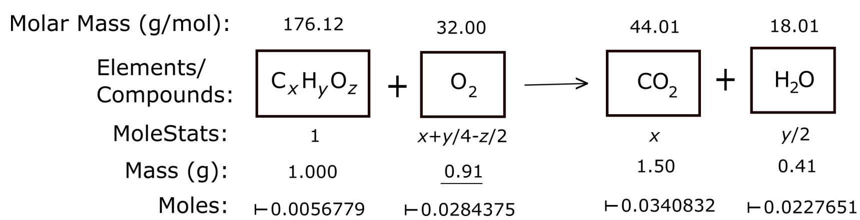

Figure 1. The 0.91 grams of O_2 in column 2 is determined by the conservation of mass between the reactants and products; hence, the underlining used in column 2, according to the markup rules we've adopted.

Step 3. We can easily calculate x by using columns 1 and 3:

$$\frac{x}{1} = \frac{0.0340832}{0.0056779} \approx 6\,. \tag{5}$$

So, we'll accept the integer value of x to be six. We can also easily calculate y by using columns 1 and 4:

$$\frac{y/2}{1} = \frac{0.0227651}{0.0056779} \approx 4\,. \tag{6}$$

So, we'll accept the integer value of y to be eight. Finally, we can calculate z by using columns 1 and 2, and by substituting in the values of x and y we've just found:

$$\frac{x + y/4 - z/2}{1} = 8 - z/2 = \frac{0.0284375}{0.0056779} \approx 5\,. \tag{7}$$

Hence, $z = 6$.

We can calculate the molar mass of $C_6H_8O_6$ and find it to be 176.12 g·mol^{-1} — the same value for the given value of the molar mass of the compound. Therefore, the molecular formula of the compound is $C_6H_8O_6$.

3 Appendix: How to interpret the Stoich diagrams

There are four main types of data in the stoich diagrams I make. The most common are data from given information, from the coefficients of the balanced equation, and from data tables, such as a periodic table of elements for molar mass information. This kind of data I do not mark up. The second kind of data in stoich diagrams comes from computations based on data in the same column, for which I use the turnstile ($\vdash$) to indicate. The third kind of data is a result in one column that required data from at least one other column to calculate it, and I indicate that kind of value or result by use of the underlining. The fourth kind of data in the figures is the result of combining given information to derive a secondary value. I indicate this kind of data with a right arrowhead ($\blacktriangleright$).