Math Diversion Problem 891

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And a little humility would go a long way.
— Hardy to Ramanujan
(According to the movie,
*The Man Who
Knew Infinity*)

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Source:  https://www.quia.com/files/quia/users/lockarm/stoichiometry
    /activity---Stoichiometry-Word-Problems-2-SOLUTIONS.pdf
Title: A Combustion Problem
  Presenter:  Patrick
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Definitions:

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

1 Problem

Nitroglycerin, $C_3H_5(ONO_2)_3$, was invented in 1846 by an Italian chemist named Ascanio Sobrero. Nitroglycerin contains both an oxidant and a fuel. When it detonates, it decomposes to form carbon dioxide, water, nitrogen, and oxygen, all in a gaseous state. Every mole of the explosive that decomposes in this way generates a tremendous amount of energy – approximately 1.5 MJ (1 MJ = 1 megajoule = 1×10^6 J = 1 MJ).

a. If 1.135 kilograms of nitroglycerin detonates, how many total liters of gas (assuming STP) are produced?

Balanced Equation:

$$4C_3H_5(ONO_2)_3 \to 10H_2O + 12CO_2 + 6N_2 + O_2 \tag{1}$$

Ans: 812 liter.

b. How much energy is produced by the explosion?

Ans: 7.5 MJ.

SOLUTION:

Step 1.

Our first task is to calculate the volume of the products at STP. We will treat all the products as ideal gases, even the water because of the extreme heat generated. Now, we know that all ideal gases take up the same volume per mole, n, at the same temperature and pressure.

Step 2. Make a stoich diagram.

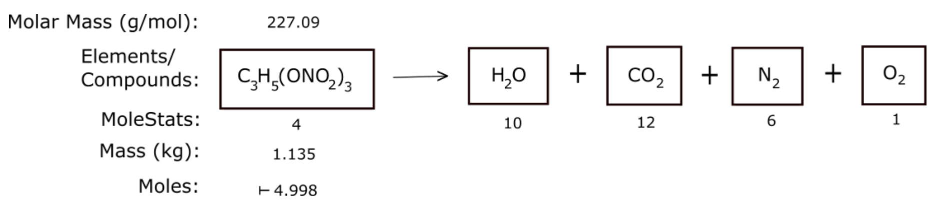

Figure 1. Four moles of nitroglycerin produces $10 + 12 + 6 + 1 = 29$ moles of an 'ideal gas mixture'. Part of problem solving is knowing when different things are the 'same' and when the 'same' things are different.

The stoichiometric proportion of interest to us from the figure is

$$\frac{4.998}{4} = \frac{n}{29}\,. \tag{2}$$

Solving this for n yields 36.24 moles. At STP a single mole of ideal gas takes up 22.4 liters. Therefore, the volume we seek is

$$V = n(22.4\,\mathrm{L}\cdot\mathrm{mol}^{-1}) = 811.7\,\mathrm{liters}\,. \tag{3}$$

The answer to Part b is easy. Since 1 mole of the explosive produces 1.5 MJ of energy, 4.998 moles produces 7.497 MJ of energy.

2 Appendix

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 (⊢) 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 (▶).