Math Diversion Problem 840

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Every big idea needs someone to defend it.
— Cybersecurity

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Source: https://www.youtube.com/watch?v=qvOVXg24Npo
Title:  Finding Volume of Evolved Gas not at STP
  Presenter:  Tyler DeWitt
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Problem

If 85.3 g of NaN_3 decomposes at 75°C and 2.30 atm, what volume of N_2 will be made? (Ans: 24.5 L)

SOLUTION. **Step 1**

We begin with a balanced equation.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)\,. \tag{1}$$

Now, we will solve the problem for the volume V using the Ideal Gas Law $PV = nRT$ to solve for the volume in terms of the pressure ($P = 2.30$ atm), the temperature ($T = 348$ K), and the moles (n) of the N_2 gas. To help us calculate n, we'll employ a stoich diagram:

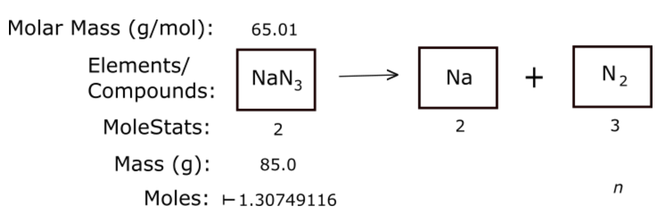

Figure 1. A sparce diagram, displaying only data relevant to solving this problem. N_2 is treated as an ideal gas with mole count n.

We need a word about the notation in the above figure. 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 (▶).

Next, we write down our mole proportion from columns 3 and 1:

$$\frac{3}{2} = \frac{\text{moles } N_2}{\text{moles } NaN_3} = \frac{n}{1.30749116\,\text{mol}}\,. \tag{2}$$

Solving for n, we get

$$n = 1.96123674\,\text{mol}\,. \tag{3}$$

Step 2.

Solving the Ideal Gas Law for V, we get

$$V = \frac{nRT}{P}\,. \tag{4}$$

Using $R = 8.2057 \times 10^{-2}\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}}$, we have

$$V = \frac{(1.96123674\,\text{mol})(8.2057 \times 10^{-2}\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}})(348\,\text{K})}{2.30\,\text{atm}} = 24.3\,\text{L}. \tag{5}$$