Math Diversion Problem 897

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Zathras is used to being beast of burden to other
people's needs. Very sad life... Probably have
very sad death. But, at least
there is symmetry.
— Zathras (a character on Babylon 5)

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Source: https://www.alvinisd.net/cms/lib03/TX01001897/Centricity/
                Domain/4240/practice%20test%20stoich.pdf
 Title:  Mystery Hydrocarbon C_xH_y, Prob. 14, p.2
  Presenter: Patrick
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Definitions:

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

1 Problem

A given sample of some hydrocarbon is burned completely and it produces 0.44 g of CO_2 and 0.27 g of H_2O. Determine the empirical formula of the compound.

a. CH b. C_2H_3 c. CH_2
d. C_2H_5 e. CH_3

Ans: e.

2 SOLUTION

Step 1.

We'll begin by finding a balanced equation, starting with

$$C_xH_y + aO_2 \to bCO_2 + cH_2O\,, \tag{1}$$

where a, b, c are positive integer coefficients to be solved for in terms of unknowns x and y. To that end, we must have the coefficients cooperate with balancing the carbon, hydrogen, and oxygen:

$$\begin{array}{rcl} \mathrm{C} & : & x = b \\ \mathrm{H} & : & y = 2c \\ \mathrm{O} & : & 2a = 2b + c \end{array} \tag{2}$$

On solving a, b, c in terms of x and y, we get

$$\begin{array}{rcl} a & = & x + y/4 \\ b & = & x \\ c & = & y/2 \end{array} \tag{3}$$

Step 2. Once again, a diagram.

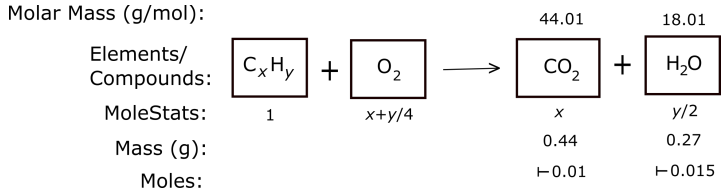

Figure 1. This sparse diagram is enough to find the ratio of x to y.

Step 3.

Next, we write down our mole proportion between columns 3 and 4:

$$\frac{x}{y/2} = \frac{0.01}{0.015} \tag{4}$$

But this is only one equation for two variables. No, we don't need another equation because all we need is the ratio of the two variables this time. Solving for x/y, we get a $1/3$. Therefore, the empirical formula is CH_3.

3 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 ($\vdash$) 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 ($\blacktriangleright$).