Math Diversion 944

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> Since the mathematicians have invaded the theory of
> relativity, I do not understand it myself anymore.
> — Albert Einstein

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Source:https://www.algebra.com/algebra/homework/word/mixtures/
                  Advanced-mixture-problems.lesson
Title: A mixed-rate problem
 Presenter: Patrick
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1 The Problem

A sample of a compound contains two types of elements, Type1 and Type2. Find the empirical formula of the compound if the following claims are true:

a) The percentage of Type1 element by mass is 84.80%.[1]

b) The percentage of Type1 element by moles of atoms in the compound is about 27.27%.

c) When decomposed, the compound releases a gas (the Type2 element) that is able to ignite a smoldering flint.

Solution:

We begin with Claim c) to conclude that the gaseous element/compound evolved is oxygen, O_2. Let's label the Type1 element E1. Thus, the compound is $E1_aO_b$.

[1] These percentages are approximate values.

Next, a diagram:

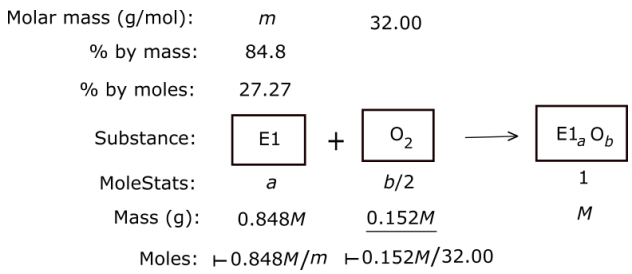

Figure C1. We are free to represent the molar mass of E1 as m, and the total mass of $\mathrm{E1}_a\mathrm{O}_b$ as M. The information in Claim a) is already incorporated. I regard the diagram as a 'parts-to-whole' construction, not a chemical reaction, per se, but either interpretation works.

Next, we can utilize the information in Claim b) to

$$\frac{0.848M}{m} = 0.2727\Big(\frac{0.848M}{m} + 2\frac{0.152M}{32.00}\Big)\,, \tag{1}$$

where the 2 arises in the second term on the right because we are counting moles of oxygen atoms, not moles of oxygen molecules. So, on solving (1) for m, we get

$$m = 238.07\,\mathrm{g{\cdot}mol^{-1}}\,. \tag{2}$$

Hence, we conclude that E1 is uranium, U.

Now we can calculate the ratio b/a by use of the mole proportion between columns 2 and 1:

$$\frac{b/2}{a} = \frac{\dfrac{0.152M}{32.00}}{\dfrac{0.848M}{m}} = 1.3335\,. \tag{3}$$

Therefore, $b/a = 2.667$, which is about $8/3$. Hence, the empirical formula of the compound is $\mathrm{U_3O_8}$.

Comment: This problem is meant to be an exercise in algebra and logic within the domain of chemistry, but I'm too ignorant of real chemistry to know whether or not this kind of problem would ever come up in real chemistry.