

Math Diversion Problem 887

P. Reany

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Every big idea needs someone to defend it.

— Cybersecurity

Source: <https://www.calstatela.edu/sites/default/files/dept/chem/07winter/201-lec/201-1-4-gravimetric-analysis.pdf>

Title: A Gravimetric Analysis Problem 3

Presenter: Patrick

1 Problem

Definitions:

FW = Formula weight = molar mass

ppt = precipitate

At wt = atomic weight

A mixture of mercurous chloride (FW 472.09) and mercurous bromide (FW 560.99) weighs 2.00 g. The mixture is quantitatively reduced to mercury metal (At wt 200.59) which weighs 1.50 g. Calculate the quantities of mercurous chloride and mercurous bromide in the original mixture. (I modified the question to fit the answer given.) ANS: 0.5182 g

2 Problem

Step 1.

We clearly have yet another before-and-after process, but what should we identify as the main invariant of this process? Obviously, it's the conservation of the moles of the mercury from beginning to end. We also have a 'total is the sum of its parts' equation in which we know the total mass of both mercurous compounds

$$(\text{grams Hg}_2\text{Cl}_2) + (\text{grams Hg}_2\text{Br}_2) = 2.00 \text{ g}, \quad (1)$$

Let's set $x = \text{grams Hg}_2\text{Cl}_2$, then $\text{grams Hg}_2\text{Br}_2 = 2.00 - x$.

Step 2.

Now, make a ‘stoich’ diagram to organize all the information. Be sure to label the rows precisely!

Molar Mass (g/mol):	472.09	560.99	200.59		200.59		
Substance:	Hg_2Cl_2	+	Hg_2Br_2	→	Hg	+	???
Mass (g):	x		$2.00 - x$		1.50		
Moles:	┆ $x/472.09$		┆ $(2.00 - x)/560.99$		┆ 0.0074779		
Moles Hg in substance:	┆ $2x/472.09$		┆ $2(2.00 - x)/560.99$		┆ 0.0074779		

Figure 1. Our interest is the conservation of the moles of mercury. The conservation of mass of the two reactants is not of direct interest to us, but, rather, their total mass of 2.00 g provides a constitutive relationship between the masses of their respective mass contents.

Step 3.

We know that the moles of mercury is conserved:

$$(\text{moles Hg in Hg}_2\text{Cl}_2) + (\text{moles Hg in Hg}_2\text{Br}_2) = \text{moles Hg recovered} . \quad (2)$$

From the last line of Figure 7, we have that

$$\frac{2x}{472.09} + \frac{2(2.00 - x)}{560.99} = 0.0074779 . \quad (3)$$

The reason for the 2’s in the numerators of the fractions in the last equation result from the fact that for each mole of Hg_2X_2 we get 2 moles of Hg. Now, after using WolframAlpha to solve the last system of equations simultaneously, I got

$$x = 0.518 \text{ g}, \quad 2.00 - x = 1.482 \text{ g} . \quad (4)$$

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 (┆) 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 (►).