Math Diversion Problem 800

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> The definition of a good mathematical problem is the mathematics
> it generates rather than the problem itself.
> — Andrew Wiles

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Source: The Ether of Great Mathematical Ideas
Title:  Word Problem
 Presenter: Patrick
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1 Problem

This problem is taken from *Chemical Principles: The Quest for Insight* ([1], Problem L16, p. F87).

PROBLEM:

A tablet of vitamin C was analyzed to determine whether it did in fact contain, as the manufacturer claimed, 1.0 g of the vitamin. One tablet was dissolved in water to form 100.00 mL of solution, and 10.0 mL of solution was titrated with iodine (as potassium triiodide). It required 10.1 mL of 0.0521 M I_3^-(aq) to reach the stoichiometric point[1] in the titration. Given that 1 mol I_3^- reacts with 1 mol vitamin C in the reaction, is the manufacturer's claim correct?

SOLUTION:

We begin with recognizing what we must actually show. We must show 1) that our calculation of the quantity of vitamin C in the original solution must be 10 times that in the titrated solution, and 2) that our calculation for the vitamin C contents of the titrated solution must lie between 1.04 g and 0.95 g in order to round to 1.0 g.

Normally, at this point I'd produce a balanced chemical equation of the reaction, but this time I won't, principally because the products of the reaction aren't given because they're not needed. What we are given instead is the stoichiometric ratio of vitamin C consumption to I_3^- consumption being 1 : 1. But we can, and should, still produce a diagram of the reaction.

[1] That is, when all the vitamin C was consumed.

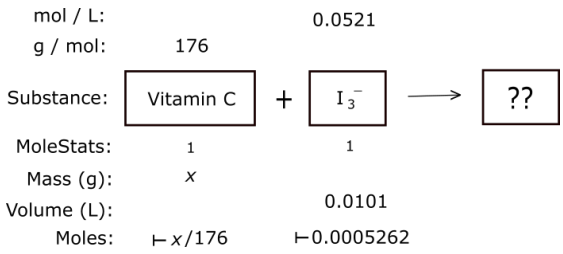

Figure 22. Note: The volume has been converted from mL to L.

But first a word about the notation in the diagram: When I use the double question mark '??', I refer to a quantity that I'm **not** interesting in knowing, probably because it's irrelevant to the problem.

Next, we write down the mole proportion between columns 1 and 2:

$$\frac{1}{1} = \frac{\text{moles Vit C}}{\text{moles } I_3^-} = \frac{x/176}{0.0005262}\,. \tag{1}$$

Solving for x, we get

$$x_{10} = 0.0926\,\text{g}\,, \tag{2}$$

where x_{10} is the mass corresponding to the 10.0 mL volume. Therefore, we multiply it by ten to get the 100.00 mL mass (approximately):

$$x_{100} = 0.926\,\text{g}\,. \tag{3}$$

However, this values lies outside the predetermined appropriate range. Therefore, the answer to the question posed is No.

References

[1] P. Atkins and L. Jones. *Chemical Principles: The Quest for Insight*, 3rd Ed. Freeman (2005).

[2] R. Blitzer. *Intermediate Algebra for College Students*, 3rd Ed. Prentice-Hall (2002).

[3] M. Hein and S. Arena *Foundations of College Chemistry*, alternate 12th ed, John Wiley & Sons (2007), 421–422.

[4] H. Rolf. *Finite Mathematics*, 5th Ed. Brooks/Cole (2002), p. 57.

[5] M. S. Silberberg. *Chemistry: The Molecular Nature of Matter and Change* 4th Ed. McGraw-Hill (2006).