A Letter from Dalton: Instructor Guide

Title

A Letter from Dalton

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Discipline

Chemistry and Biochemistry

Target Audience

Introductory, majors or nonmajors

Keywords

Atomic theory, compounds, empirical formulas, mass laws, stoichiometry

Length of Time/Staging

Students work together during one 50-minute class, then meet outside of class to finish the problem before the next class meeting.

Abstract

In this problem students must analyze mass data to test a hypothesis proposed by Dalton as a consequence of his postulates concerning the atomic nature of matter. The analysis is done using only concepts available in 1804, forcing the students to wrestle with the proper way to compare mass data in order to find meaningful relationships among elements. They discover, among other

things, the ambiguities associated with writing formulas in the absence of standard atomic masses.

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Format of Delivery

The problem poses several questions, which students work through in groups of four. Each group turns in a written report of their solutions, reports out for one section of the problem, and participates in a whole-class discussion of the problem.

Student Learning Objectives

1. To recognize the implications of an atomic model in the mass-related behavior of matter.
2. To understand the difficulties encountered by early chemists in trying to analyze mass data in the development of atomic theory.
3. To recognize the connection between mass relationships and chemical formulas, and the importance of standard atomic masses in developing those formulas.
4. To understand the distinction between molecular and empirical formulas as that relates to identifying compounds.
5. To be able to explain mass behavior in light of the postulates of atomic theory, and to be able to predict behaviors based on those postulates.

Student Resources

A standard general chemistry textbook

Instructor Resources

Atomic hypothesis and discrete nature of matter
at Selected Classic Papers from the History of Chemistry
provided by the Classic Chemisty site at Lemoyne College
https://web.lemoyne.edu/giunta/papers.html#atomic

Author's Teaching Notes

This problem is the first one used in the first semester of a general chemistry sequence for honors science (but not chemistry) majors. Groups are constructed semi-randomly, with an attempt being made to balance chemistry background and gender. Preceding this in class had been a discussion centered around nanotechnology, and a brief mini-lecture about some important stages in the development of the atomic model. That ended with the mention of the laws of mass conservation and constant composition, and with the introduction of Dalton—without any discussion of his postulates.

Students can find it difficult to understand the hypothesis proposed in the problem (the basis for the law of multiple proportions), so it is important to check with each group to be sure they understand what they are trying to test with the data, before they get too far off track. Once the idea of using normalized masses is there, the rest of the problem flows smoothly. Many students are convinced that compounds with the same physical appearance must be the same, so the third question provides a good opportunity for probing the necessary vs. sufficient conditions for two substances to be the same, as well as for introducing the idea of isomers.

Assessment Strategies

Group reports are critiqued after the general discussion. Exam questions include interpreting "particle" pictures of chemical reactions in terms of the atomic postulates, examining mass data to see which mass laws hold or are violated, and proposing what data to collect and how to analyze it from an experiment, to test whether the experiment demonstrates different mass laws.