# Chemistry Chat

## When a Teacher Is at a Loss in High School

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## 1. Introduction

In the previous chat,[1] I introduced the difficulty of keeping up with the changes in high school chemistry. In this paper, I reluctantly disclose examples of how I am at a loss regarding what to do when students ask me questions that I cannot answer appropriately. If I had sufficient knowledge and experience, I could promptly satisfy the students.

## 2. Which is the best method for measuring molecular weight?

In Japanese high schools, students learn how to measure molecular weight (or formula weight) using the following four methods[2]:

– Gas equation (Dumas method)
– Elevation of boiling point
– Depression of freezing point
– Osmotic pressure

The appropriate method must be selected according to the compound, and these methods are not always realistic because we have to consume a sample in grams (exceptions apply). Moreover, it is difficult to obtain accurate molecular weights because special techniques are required to avoid technical errors. As a result, the experiment is no longer a measurement of molecular weight but a competition involving measurement skills. We often receive requests from students who want to accurately determine molecular and formula weights using smaller quantities and simpler methods. However, this is not easy with these methods, thus I am at a loss how to respond to students.

In Japanese high school textbooks, mass spectrometry is not described in detail, only appearing in a topic section.[2] If Japanese students in general courses encountered a mass spectrometer, it would make a great impact on them because of its simplicity and accuracy. On the other hand, in the International Baccalaureate course, students learn practical mass spectrometry.[3] To my great surprise, interpretation of electron-impact mass spectra was given in the Common Test for University Admissions in Japan, 2024.[4] Even though cognitive thinking is important, I will be at a loss how to answer the Exam coverage when students ask me.

## 3. Why do so many compound names end in “[n]”?

Students and colleagues often ask this question, but I am at a loss because I do not have any answers. The names of organic compounds that are popular in our daily life often terminate with an [n] pronunciation and have the following suffixes:

- Hydrocarbons : -ane, -ene, -yne (e. g., methane, polyethylene, toluene)
- Nitrogen-containing compounds: -in, -ine (e.g., glycine, adenine, caffeine)
- Antibiotics: -in (e.g., streptomycin, penicillin)

Why are there limited suffixes corresponding to the compound classes? If I told the students that suffixes followed the IUPAC nomenclature rule,[5] they would never be convinced of my answer. Relying on my own personal knowledge, I do not have any answers to date. I wish to ask experts about this nomenclature.

## 4. How do I explain the amount of substance?

The definition of "amount of substance" was changed in 2019,[6a] and we have to change its explanation accordingly. However, an experienced teacher in our school insisted that a conventional explanation would be more understandable to students than the updated one:

(Previous Explanation)[6b]

*The mole is the amount of substance in a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is "mol".*

The number of $^{12}$C atoms in 12 g of carbon 12 was experimentally determined as 6.02...×$10^{23}$ /mol, which is called the Avogadro constant, $N_A$. The Avogadro constant and standard of mass (kilogram) were determined independently and contain errors.

(Current Explanation)[6a]

*One mole contains exactly 6.02214076 × $10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, $N_A$, when expressed in mol$^{-1}$.*

In other words, we determined that one mole is a collection of exactly 6.02214076 × $10^{23}$ particles. Consequently, the mass of one mole of carbon 12 was revised to 11.9999999958 g.

Even after the change, the mass of one mole of $^{12}$C atoms is the same as before, within the range of significant decimal places used in high school chemistry (usually up to three digits). I introduce only the current definition to my students and omit the historical background to avoid confusion and to save class time. We must proceed to the next difficult topic, a stoichiometry calculation. I usually agonize over whether or not I should tell them the history.

## 5. Conclusion

Every day I encounter topics that are difficult for a high school teacher to explain, but many topics are probably obvious to experts. From an educational standpoint, it is a good way to entrust questions to students so they can find answers. However, as a chemist, I wish to find answers by myself. At the very least, when I know a thing, to hold that I know it; and when I do not know a thing, to allow that I do not know it.[7]

## Amendment/Acknowledgments

The topic of molecular polarity was introduced in the previous article.[1] One of the readers pointed out that it was incorrect to judge the polarity of a liquid flowing out of a burette by whether the flow bent when a charged rod was brought close to it. The reader stated that the bending of the water flow was based on a phenomenon called "electrostatic induction," in which water is attracted to charged substances, and is not attributed to the polarity of the molecules. Details are available in reference 8. I express my deep appreciation for this suggestion.

## References and Notes


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He graduated the University of Tokyo in 1989 and received his Ph.D. degree from Graduate School of the University of Tokyo in 1994. He has worked in Nippon Suisan Kaisha, Ltd., RIKEN, Tokyo Chemical Industry Co., Ltd. and Junten Junior and Senior High School. He has concurrently served as an adjunct lecturer in Tokyo University of Agriculture and Technology, Tokyo Denki University, Graduate School of Yokohama City University, Rikkyo University, and Nihon University. In 2020, he was appointed as a science teacher in Toyo University Keihoku Senior High School.

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