Chemistry Chat

Difficulties in Senior High School Chemistry Experiments

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1. Introduction

Senior high school chemistry textbooks in Japan contain procedures and tips for student experiments. It is quite natural for teachers and students to expect that the experiments proceed as anticipated, since chemical experts supervise the textbooks. However, when we try the experiments, we sometimes encounter results that do not meet our expectations and thus we do not reach a proper understanding of the subject. In addition, experiment time is limited because the time required for preparation and cleanup cannot be ignored. I would like to discuss these difficulties in senior high school chemistry.

2. Sublimation of Iodine

In senior high school "Basic Chemistry" course, students learn that sublimation is one of the methods for the separation of mixtures. Sublimation is a phenomenon in which a solid directly becomes a gas. For example, iodine and carbon dioxide, which are molecular crystals, easily sublimate. However, if you put pieces of iodine in the bottom of a test tube or a beaker and heat it with a burner, you can observe not only purple vapor from solid iodine but also purple liquid of iodine. Heated iodine does not only become a gas directly from a solid, but also via a liquid. The melting point and boiling point of iodine are 114 °C and 184 °C, respectively. You can find solid iodine melts and sublimes. In this experiment, students observe not only sublimation but also melting. Students who have preconceptions that melting and sublimation occur separately are confused.

In the actual experiment, the sublimation technique is demonstrated to separate pure iodine from a mixture of sand and iodine.[1] It would be difficult to observe the liquid iodine in the sand. How ingenious the experiment is!

Figure 1. Sublimation of iodine

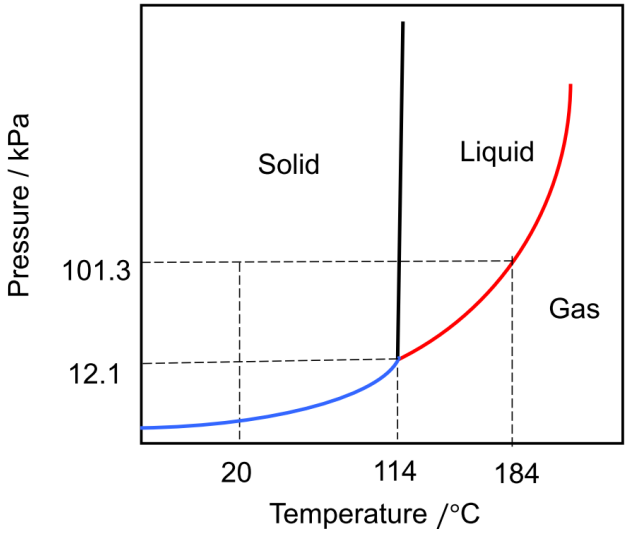

Figure 2. Phase diagram of iodine (modified from Reference 2)

3. Unit Lattice Models of Metal Crystals

In "Basic Chemistry" or advanced "Chemistry" courses, students learn two basic models of unit cells of metal crystals: body-centered cubic (bcc) and face-centered cubic lattice (fcc). The topic of this section is aimed at understanding the filling factor and coordination number. To aid student understanding, we use Styrofoam models. However, it is difficult to cut a Styrofoam sphere manually and precisely with a cutter knife into 1/2, 1/4, and 1/8 pieces. Using a conventional cutter knife, a Styrofoam cutter that heats and melts by a nichrome wire, the cross section usually becomes uneven. The textbook also introduces a method of using a cutter knife to cut the sphere in one stroke.[3] In many cases based on my experience, these activities fail to achieve the objectives to understand the arrangement of atoms in the unit lattice. Our school purchased commercially available Styrofoam models (**Figure 3**) for students to observe.

Figure 3. Commercial models of bcc and fcc lattices (Courtesy of NaRiKa Co.)

Recently, a conventional method has emerged for cutting Styrofoam accurately and easily.[4] As a jig, a plaster mold is manually prepared to fit half of the sphere of Styrofoam. The plaster surface is then smoothed by sandpaper. Simply sliding a cutter along the surface gives one-half of a sphere with a smooth cut surface.

The cut spheres fit closely into a cubic acrylic box that is available at a 100-yen store. The benefits of this method are that it is reproducible and inexpensive. However, the teacher's working time to prepare the experiment is considerable.

4. Is NaCl Aqueous Solution Basic?

A normal salt is a salt in which neither H (acidic) nor OH (basic) remains in the substance. There is an experiment to determine rules of pH of salts based on the strength of the original acid and base. Three types of salts are used in combination with the acid-base strength, such as sodium chloride, ammonium chloride, and sodium acetate.

Table 1. Properties of aqueous solutions of normal salts

Normal Salt	Acid	Base	Property
NaCl	HCl (strong acid)	NaOH (strong base)	?
NH_4Cl	HCl (strong acid)	NH_3 (weak base)	Acidic
CH_3COONa	CH_3COOH (weak acid)	NaOH (strong base)	Basic

When we use reagent-grade sodium chloride, its solution is neutral (green by addition of the indicator BTB (bromothymol blue) solution). However, if "table salt" is used instead, its aqueous solution becomes basic (blue by BTB solution). The reason is because table salt contains basic magnesium carbonate as an anti-sticking agent.

This experiment shows the importance of preliminary experiments and the use of appropriate substances.

5. Conclusion

We use various kinds of reagents and equipment in chemical experiments in senior high school. Experimental techniques should be easy for students to understand. However, it is difficult for instructors to find the technical information suitable for their classes in authorized databases such as SciFinder®. Teachers/instructors should catch up with innovative experimental techniques not only from the literature but from other sources.

References

1. K. Tatsumi, *et al*. "Basic Chemistry, Revised Edition" published by Suken Shuppan, Tokyo, 2021, p. 23 (Japanese senior high school official textbook).
2. M. P. Jansen, *Chem. 13 News Magazine* **2015**, *10*.
3. K. Tatsumi, *et al*. (2012), "Chemistry, Revised Edition", Suken Shuppan, 2021, p. 26 (Japanese senior high school official textbook).
4. T. Yoshida, "Crystal Models Using 100-Yen Shop Clear Cases," 8th Workshop for Teaching Science (Chemistry) in Junior and Senior High School, Toho University. 2022.
5. H. Fujii, N. Noda, *Bull. Soc. Sea Water Sci. Japan* **2017**, *71*, 39. (Japanese)

Author Information

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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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