

## The new Course of Study and chemical education in high schools

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### Chemical education in high schools—its importance and complexity

The Course of Study for high schools has been revised for the first time in ten years, taking effect as of April 2012. Many university professors probably have little interest in chemical education at high schools unless they are engaged in writing textbooks or making questions for the university entrance examination. But, I think that what is taught in chemistry from elementary to high school and how it is taught are an issue as important as improving chemical education in universities and graduate schools to develop world-class human resources. To have many pupils and students take an interest in the structure and changes of physical matter not only leads to increasing the number of young people who study chemistry but also enables everyone in society to make appropriate decisions on various daily events from a scientific perspective, which I think is necessary in a wholesome society.

The circumstances surrounding high school chemical education are complex. There is non-uniformity between students in the liberal arts course who finish chemistry studies at high school and those in the science course who continue further studies at university. Consideration must also be given to the balance between chemistry and other science subjects. Furthermore, what makes high school education more complex is that the courses and their content, while bound by the Course of Study laid down by the Ministry of Education, Culture, Sports, Science and Technology, are required to provide all materials necessary to prepare students for the final goal of entrance examinations administered by each university and the National Center for University Entrance Examinations. According to the Course of Study, the objectives of studying chemistry-related subjects are “to develop the ability and attitude necessary for chemical research and to enable understanding of the basic concept, principles and rules of chemistry.” I am sure high school teachers and university professors have no objections to fostering and accepting students with such abilities. At present, however, high school teachers lament over not having enough time to conduct exploratory lessons incorporating observations and experiments they want to do due to preparations for university entrance examinations, and are suffering under time constraints. On the other hand, university professors voice dissatisfaction over not having freedom in making questions for the entrance examinations

because of requirements of the Course of Study. Isn't there an approach to chemical education that would be desirable to both high school and university and at the same time satisfy the philosophy of the Course of Study?

### Expectations on the newly established “chemistry basics”

In the new Course of Study taking effect in April 2012, some revisions have been made in consideration of the issues revealed by the current Course of Study. The biggest revision in science subjects, taking chemistry as an example, is the reorganization of the current course of Chemistry I and II, each with three credits, into a new course of two-credit Chemistry Basics and four-credit Chemistry. Also, the new Course of Study requires students to study three of the four basic science subjects of physics, chemistry, biology and earth science. This is in accordance with the Course of Study's philosophy that “acquiring a wide range of basic scientific knowledge is important in today's ‘knowledge-based society’.” This revision is significant in the sense that the burden of learning chemistry will be decreased for students in liberal arts course who finish chemistry studies at high school from the current three-credit Chemistry I to the two-credit Chemistry Basics. In the new Chemistry Basics, chemical bonds are treated systematically, and emphasis is laid on having students thoroughly understand the quantitative relations in chemical reactions. Because studies of inorganic matter and organic compounds previously included in Chemistry I were transferred to four-credit Chemistry, liberal arts students would be relieved from the memorization of detailed properties related to inorganic matter and organic compounds. Since I think “basic scientific knowledge” in chemistry is learning how matters familiar to us are constituted, what determines their properties, and what kind of rules govern their changes, I place my hopes in the new subject of Chemistry Basics that contains these elements. However, to have students taking this course maintain their interest in chemistry and establish their learned knowledge as scientific knowledge, I think it is necessary for teachers to skillfully take up familiar matters as examples to show their relevance to what they have studied, and teach the principles and rules of chemistry from the perspective of why we should think in that way. It is also important that questions be set along the lines of this philosophy in the National Center Test for University Admissions.

### Why does chemistry mean memorization?

For students in the science course studying four-credit Chemistry, there is little difference from the current course except for the surprisingly thick textbook. More than half of the latter part deals with unremitting descriptions of inorganic substances, organic compounds and polymers, that are so-called particular fields. Studying chemical formulae and properties of physical matter may be enjoyable for students already interested in chemistry, but would be painful work for most of the other students in the science course. Should they think of chemistry as being about memorization, it would be almost impossible to acquire new students with an interest in chemistry.

For example, the new Course of Study mentions that “the structure of nucleic acid” be covered in “the property and usage of polymers” of four-credit Chemistry. Accordingly, the structure of nucleic-acid base, the appearance of base-pair formation, and the structure of the DNA double helix are included in the new Chemistry for all students to study, which in itself is definitely not a bad thing. As a student, I was amazed to learn that the things happening within our living body could be described as ordinary chemical reactions; the experience of which has been a trigger in electing my current field of study. Maybe, what the Course of Study expects also lies somewhere around there. Students, however, are bound to pose to their teachers the naïve question of “Do we have to memorize the structure of nucleic-acid base?” to which teachers would probably answer, “It would be better to memorize it, because past entrance examinations have been favorable to those who have studied the structure.” Thus, students have to memorize an enormous amount of items in particular fields just for the reason that they may be tested on them in the entrance examination. University professors have never wished to take in students who have memorized every detail of the textbook, so why does it turn out this way?

As Professor Tadashi Watanabe has previously pointed out in the Editorial<sup>1)</sup>, there are many reactions and study items “useless to university studies and having nothing to do with day-to-day life” mentioned in the textbooks that have repeatedly been tested in entrance examinations. The Course of Study has been often criticized for inappropriate high school courses, but it only sets down an outline. For example, as for organic compounds containing functional groups in the explanatory comments of the Course

of Study, it mentions only “to take up typical compounds such as alcohols, ethers, carbonyl compounds, carboxylic acids and esters to explain how properties are characterized by functional groups and show their relationships through reactions and structures.” However, at some point, the reaction “aldehyde reduces Fehling’s solution,” which is unfamiliar even to organic chemists, has been included in every textbook only because the reaction has been tacitly acknowledged as an item to be memorized by high school students.

### Is it possible to review the course content?

Under such circumstances, I strongly feel the necessity to review the content of the high school chemistry course and alter it in accordance with what today’s students need to learn. As mentioned above, it is quite possible to change specific items and subjects that high school students must learn within the framework of the Course of Study. On this occasion, I feel it is important to clarify the concepts, principles and rules of chemistry that high school students must learn as a minimum requirement and the items to be memorized, and have them shared by high school teachers and university professors. In order to conduct such a review, discussions must be carried out at both high school and university levels, and textbooks must be revised all together with the understanding of publishers and officials authorizing school textbooks. The work would require considerable time, but the current situation will never change unless it is carried out. I look forward to having many members involved with universities and administration take interest in high school chemical education and create a major trend.

1) T. Watanabe, *Chemistry and Chemical Industry* **2008**, 61, 499.

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