UNIVERSITY CHEMICAL EDUCATION IN JAPAN

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The students of Japan enter universities and colleges after twelve years of education at the age of approximately eighteen. The entrance examinations are generally competitive and they vary from university to university. There are some universities which select students at the departmental level and others select for general science and social science majors only. In the former examples, a boy may enter a university as a student of the department of chemistry, whereas, in the latter, he enters as a student for a science major and, if he is interested in chemistry, he may become a student of the chemistry department after $1\frac{1}{2}$ to 2 years general education.

General education is given at all universities and colleges. Even the boy who has entered a university as a student in a chemistry department must take units of general education. He studies at the same campus with students who major in other subjects. He has to take 12 units each of humanities, social sciences and natural sciences. We have considered that it is important to educate people in general before they become specialized. The duration of this general education is $1\frac{1}{2}$ to 2 years. After this period, the student affiliates to the respective department and studies the special subject until he has graduated after at least four years residence.

There are many chemistry departments in Japanese universities. A department of chemistry is usually one of the departments in a faculty of science. The faculties of agriculture have departments of agricultural chemistry and the faculties of pharmacy and pharmacology offer organic chemistry. Even the faculty of engineering has several chemistry departments. This is so because the need of chemistry graduates in this area has expanded so largely and the faculty is primarily concerned with industrial interest. One of the interesting points in the system of the University of Tokyo is the existence of a Department of Pure and Applied Sciences in the College of General Education. In this department the aim is to provide an interwoven pattern of education and science. There are some other universities in Japan which have either a faculty or a department with similar aims.

At the graduate school level, some universities have so-called divisions of chemistry which include departments of chemistry, applied chemistry, agricultural chemistry and pharmaceutical chemistry. The idea of this system is considered fine and the merit of the division is recognized by both the students and the faculty members. Unfortunately, however, administration systems do not follow this idea because of budgetary limitations: it is impossible to have independent administration for divisions such as

chemistry, biology and mathematics with physics. Because of this and some other reasons, the graduate schools have now been reorganized and have close connection with the faculties. Deans of the faculties and the divisions of the graduate school are generally the same person and secretarial work and other support is performed in the same office. However, the merit of lectures, such as offered in the division of chemistry, has been recognized and some common courses for the chemistry graduate students are still given. The Division of Science of the University of Tokyo has a course of co-ordinated science which deals with the advanced study of the topics taken up in the Department of Pure and Applied Sciences.

A two-year residence is required to obtain the master of science degree and a doctorate candidate must enrol at the graduate school for a further three years to obtain his degree.

As to the recruitment of the graduates, the industries in Japan have been interested to employ people who can be of immediate use upon graduation; thus industries have the tendency to recruit from the departments of applied chemistry. Naturally, therefore, the graduates of the department of chemistry tend to pursue academic careers. Recent developments in chemical industry, however, have made industry consider the value of employing pure research chemists. They are now hoping to recruit M.Sc. from every department and even a D.Sc. from a department of chemistry is welcomed these days. University graduates are often treated as if they are technicians.

We must recognize, from the above discussion, that the image of university has changed completely. Social needs have changed also. Since Japanese universities have sought to educate people in rather narrow specialization, it is fairly hard to meet these social needs. This is reflected by the number of student enrolments. The ratio of the university students to the population of the same age is now 20 per cent and this ratio is expected to increase up to 40 per cent within 15 years. Clearly we do not need so many specialized people. We have learned this even from the bitter experiences of student unrest since 1968.

If one takes the Department of Chemistry of the University of Tokyo, as an example, the situation will become clear. A student who joins the Department has to take 64·5 units to graduate and only four units of the necessary 64·5 are elective. Faculty members have decided that if basic items are considered, this much has to be taken in order to be recognized as a graduate of the Department. It is clear that the faculty members are aiming to educate chemistry specialists but many students feel that there is too little freedom: the students would like to select according to their will. This difference in approach is considered to be one of the reasons for the riots.

Many changes in the university system have been proposed by various groups, but it seems that there is a common feeling that the university should have different aspects in an educational system. At least two types may be considered. One is the university of the classical type. Although many students may wish to choose their course by themselves, there are also many students who like to study a narrow specialized field. There is no evidence that the classical way of education is defective. It will not be wise to give up the classical way at least until it is found to be inferior to a new one. The second is the university where maximum freedom is allowed for the students.

They select courses at will, probably after consultation with faculty members.

The Department of Pure and Applied Sciences of Tokyo University aims to educate students in order to make them able to understand the basic principles of the natural sciences and apply their knowledge to various phenomena. Courses are divided into: physics with chemistry and chemistry with biology; quantum mechanics, electromagnetism and optics, chemistry of elements, polymer chemistry I, structural chemistry I, and coordinated biology are compulsory. In the lecture on chemistry of elements, the natural occurrence and distribution, the use, and the properties of the elements, including the redox potential and the ease of formation of compounds, are discussed. The lecture on polymer chemistry I treats forms of chain polymer, elasticity of rubber, statistical thermodynamics, and molecules of low and high molecular weights. In structural chemistry I, the basic principles of quantum mechanics are introduced to enable students to understand various properties of atoms and molecules.

There are other lectures pertaining to chemistry whose major topics are given below with the titles of the lectures.

Inorganic compounds: volatile compounds, inorganic polymers, and complexes of transition elements. Structural aspects of these topics are stressed, including the theory of the coordinated bond.

Organic chemistry I: optical isomerism, conformation of molecules and electronic theory of organic chemistry. Molecular orbital approach to the electronic theory is used.

Organic chemistry II: reaction conditions, mechanisms and factors influencing the outcome of the reaction are discussed, the structures of the products being included.

Structural chemistry II: Molecular spectroscopy is studied, including vibration-rotation spectra, application of group theory to the vibration spectra, n.m.r. and e.s.r.

Chemical reaction: collision theory, transition state theory, elementary reaction and net reaction, factors influencing the rate of reaction such as energy and structure, and various reactions. Understanding the reaction from the standpoint of a unifying principle is stressed.

Electrolyte solution: solution model, activity, intermolecular forces in solution, statistical mechanics of solution, and molecular structure of acids and bases.

There are some other courses such as instrumental analysis, electrochemistry, polymer chemistry II, theoretical organic chemistry and biochemistry. Laboratory exercises are also given. These lectures given in the Department of Pure and Applied Sciences are doubtless of high level and it may not be possible to raise all students to this level.

The Faculty of Science, Kyoto University has made a proposal recently which it is hoped to put into effect in 1970. The proposal is on similar lines as described for the university of general education. Courses classified as general education are given over a four-year period instead of giving them in the first two years. Thus some courses pertaining to the speciality are also given in the first and second years. The students are not affiliated to the respective department, but to three groups at the third year: mathematical sciences, physical sciences, and biological sciences.

We expect that good research chemists will be produced both in the classical universities and the proposed new universities.

As to the master's course, it is now becoming common to consider that the courses may be combined with the undergraduate course. As described earlier, graduates with master's degree are needed by industry. The doctor's course now existing will virtually vanish in the future. Although the necessity of training research chemists up to this level is recognized, it is also said that they should be given a status with salaries.

The so-called combined courses have been explored for some years at the university level. There are some attempts to combine physics and chemistry or other branches of science. However, the very successful examples of these attempts in the world have not been developed in Japan so far, certainly not at undergraduate level. The primary difficulty has been that the combined course is, in general, of a high level. A second important factor is the interest of professors: professors in Japan are usually interested in a relatively narrow field of speciality and tend to be more interested in research than in education. Thus, even though it may be desired to give a combined course in chemistry or science a professor may look at it from his own interest only.

The Ministry of Education in Japan is also interested in this kind of combined course and some groups are given funds to study developments at the undergraduate level. It is hoped some progress will be made in this area and the 'general science course' be given to students who do not major in science.