

EDUCATIONAL ACTIVITY OF THE DEPARTMENT OF INORGANIC CHEMISTRY AT THE TECHNICAL UNIVERSITY OF BUDAPEST

J. RÉFFY

Department of Inorganic Chemistry
Technical University, Budapest

Received: July 15, 1991.
Presented by Prof. J. NAGY

Abstract

A summary is given about the subjects lectured by the department for chemical engineering students. The most important task of the department is to lecture general and inorganic chemistry for first year students and to run the related seminars on chemical calculations, and laboratory practice. In the second level of tuition the department is responsible for quantum chemistry subject. Besides, the department offers some criterion and elective subjects for the students and participates in English language course at the Chemical Engineering Faculty.

Keywords: education of chemistry.

Since its foundation the Institute of Inorganic Chemistry has been teaching the subject 'General and Inorganic Chemistry' for first year students. During the years the educational field of the department was supplemented with some other subjects which were not obligatory for all students. Our main role in the training of the students, however, has always been given by teaching general and inorganic chemistry. The general chemistry is not an independent field of science, in the course of lectures in general chemistry we make the students acquainted with the most important principles of chemistry, give a basic knowledge to the subsequent chemical subjects, provide some ideas about the special fields of chemistry about which the students will get more detailed information in a later phase of the training. Besides our important target is to bring those students to approximately the same level of knowledge who came from high schools of different requirements and possessed rather heterogeneous basic knowledge in chemistry.

Related to the General and Inorganic Chemistry subject the students take part in seminars concerning chemical calculations (in the first semester) and in laboratory practices (during the first and second semesters).

From decade to decade the number of contact hours has shown a decreasing trend at the Technical University, new subjects were introduced, consequently the education of General and Inorganic Chemistry has been gradually reduced to smaller number of weekly hours. Presently we have in the first semester 3 hours for lectures, 2 hours for seminars and 8 hours for laboratory practice, in the second semester 2 hours for lectures and 7 hours for the lab. We teach students in the evening course, too, but the number of students in this course decreases from year to year (the training includes in the first semester 4 hours/week for lectures, 2 hours for seminar and 5 hours for laboratory practice, in the second semester 4 hours for lectures and 4 hours for the lab).

The reasonable building up of the general chemistry would require first to give information about the building blocks of simple elements (the atoms) and the more complicated compounds (the molecules), then summarize the basic laws of any substance (built from atoms and molecules, respectively). For practical reasons, however, we had to deviate from this logical treatment of the subject. It proved to be useful without any doubt to give just at the beginning the most important theoretical knowledge in order to carry out experiments in the laboratory practice and solve some problems during the seminars. Therefore it was required to make the students in the first part of the lecture acquainted with the three states of matter and the changes of state, the basic knowledge in stoichiometry, the law of solutions, mixtures, the principles of thermochemistry, chemical equilibrium and electrochemistry. Even at the beginning we summarize the more important intensive and extensive variables to develop a uniform view in the students of looking at physical processes and chemical reactions recognizing the inhomogeneity of an intensive variable as the driving force of the processes.

The chapters concerning the structure of atoms and molecules are particularly important because during the education of production engineers (the first grade of our training considered as equivalent to a B.Sc. course) the students do not get any more information about this topic in other subjects, and in the second level of the tuition (chemical engineer level, equivalent to an M.Sc. course) two subjects (Physical Chemistry III dealing with the methods of structure investigations and Quantum Chemistry) rely on the knowledge given in our lectures.

In the course of lectures in Inorganic Chemistry first we summarize the properties of elements following, of course, the periodic system; for one family of elements we survey the physical properties, the structural characteristics, chemical behaviour, occurrence, production and uses. Special consideration is given to the application of the principles, learnt in general chemistry, in the interpretation of the phenomena of inorganic

chemistry, to the development of the way of thinking of the students, we emphasize the aspects of environmental protection, try to attract the attention of the students to new materials with interesting properties, to the importance of material science. The chemistry of compounds is treated according to the functionality of the elements constituting the compounds, going from the compounds of monofunctional elements (hydrogen, halogens) until the nitrides and carbides. The oxy-acids and their salts are included into the chapter dealing with oxides. On the basis of the partial charges, conclusions are drawn about the changes in the covalent, ionic and metallic bond character for a given family of compounds.

The chemical calculation practice (seminar) is connected with general chemistry. The requirements in this subject cause the first real difficulties for chemical engineering students. The most important chapters of the subject are: concentration calculations, the application of gas laws, balancing redox equations using the changes in oxidation number, the practice of IUPAC nomenclature, stoichiometric calculations, problems related to chemical equilibrium (equilibrium in electrolytic solutions, in liquid and gas phases, pH calculations, solubility product constant) and electrochemical calculations. In the lecture notes each chapter begins with a short summary on the basic theoretical background related to the problems of the chapter in question and the student can find the detailed solution of several problems to facilitate independent learning process. The last chapter of the lecture notes does not contain traditional calculation problems, but some theoretical questions are given in connection with the structure of atoms and molecules. The chemical calculations are considered to be very important for the students in the emergence of a quantitative chemical approach in the development of an original way of thinking.

During the laboratory practice in the first semester the students become acquainted with the fundamental laboratory operations, they prepare gradually more and more difficult inorganic substances requiring laboratory skill for some special operations (including precipitation, dissolution of a metal, decomposition by heating, evolving a gas and using the gas for preparation, the formation of complex compounds, simple method for the preparation of air sensitive compound, electrochemical method for preparation). Basic measurements are also carried out by the students to illustrate the applicability of theory in practice, to get to a deeper understanding of the theoretical principles, to develop the laboratory skill of the students and to train the students in measuring the simplest physical and chemical characteristics (e.g. mass measurement by balances, density measurement by pycnometer and Mohr-Westphal balance, determination

of molar mass based on vapour density measurement, freezing point depression and boiling point elevation measurement, determination of melting point and boiling point, pH measurement by colorimetric method). Since we meet students who generally encounter here first time a chemical laboratory, laboratory glasswares and all the other laboratory instruments, in the case of unsuccessful preparation or measurement these exercises can be repeated two times. An important part of the laboratory practice is that the students participate in glassblowing exercises 3 - 4 times during the semester, each time the practice takes about 2 hours.

The principal aim of the laboratory practice in the second semester is to make the students get some general knowledge about inorganic substances. There are numerous chemical reactions to be carried out. The deeper understanding of these reactions, the observation of characteristic similarities and differences are facilitated by the trends in the properties of elements and compounds, concluded from the periodic system. The exercises include observations on the colour, appearance and solubility of chemical substances and study of a fairly vast series of reactions of ions formed in aqueous solution. In the book available for the students some general questions before a chapter related to a family of the periodic system and the comprehensive questions closing the given chapter promote the deeper understanding of the experimental work and a reasonable interpretation of the observations. The control of the knowledge of the students - lacking better methods - occurs by qualitative analytical exercises, but it means in most cases the recognition of a single unknown substance based on its appearance and some characteristic chemical reactions. In a limited number the students have to analyse mixtures of substances (ions) and the identification of the ions requires the knowledge of the classification of cations on the base of different solubilities (and colour) of their sulfides, some routine in the separation procedures and the students have to be acquainted with the analytical groups of anions and the most important analytical reactions for each anion.

We consider it very important to ensure even for first year students to carry out some independent work according to their own ideas and initiatives. Thus, in the second semester during the laboratory practice the students are expected to choose a topic with the general title: My favourite reactions. All along the laboratory practice they may study a series of reactions, an interesting phenomenon detailed according to their own fancy, and at the end of the laboratory practice they report on their work in the presence of a group of students and a teacher.

For the first year students the fulfilment of the requirements in General and Inorganic Chemistry (together with the requirements of other

subjects of the semester) needs remarkable intellectual activity, and ability of enduring the early failures of their studies. Beginning in the previous academic year our system of accepting students to the Chemical Engineering Faculty has changed significantly. About half of the students are accepted without entrance examinations based on their high marks in the high school. At the same time, a larger number of students may enter the faculty, considering that the entrance examinations do not mean the best method to select which young people have the abilities to become a good chemical engineer. We would like to give the possibility for an increasing number of applicants to demonstrate their vocation during the university years. We have the responsibility to give informations to the students even at the beginning of their studies about the tasks of a chemical engineer, to increase their interest in chemistry and to help them in overcoming their initial difficulties.

The department has a role in the tuition program for students of senior years by lecturing several subjects e.g. the subject 'Selected Topics in Inorganic Chemistry' which is a so-called criterion subject (2 hours/week for one semester).

In our present two level education system the students in their second and third year are obliged to choose at least 5 criterion subjects from among more than 30 criterion subjects in order to get accepted to the second level of the education. The subjects are divided into 4 groups (major topics: mathematics; chemistry; physics-physical chemistry; biology), and the students are expected to select at least one subject from each group. The interest of the students in this subject is varying, generally 25-50% of them chooses the subject in second or third year. For two-three lectures in a semester special experts are invited from another university or a research institute (e.g. scientists dealing with X-ray diffraction, electron diffraction investigations or co-ordination chemistry have been invited for lectures).

For students in the 'Organic and biological chemical industry' section a compulsory subject in the fourth year of the studies is the subject 'Quantum chemistry' lectured by our department. In the limited time available (2 hours/week in one semester) we only have possibility to give some knowledge about the basic ideas of quantum chemistry and to illustrate how the results of quantum chemical calculations help the practical chemists e.g. in the interpretation of experimental data obtained by spectroscopic methods, predicting the molecular geometry, solving conformational problems, investigating the bond structure, clarifying the mechanism of chemical reactions, calculating thermodynamic and kinetic data. We keep in our mind that the students are not very well versed in mathematics and we try to

avoid the problem that the students lose their interest in quantum chemistry looking at the mathematical difficulties. As part of the examination the student has to carry out quantum chemical calculation for a compound using a given computer program (for semi-empiric quantum chemical calculation or Hückel method). We expect from the students the interpretation of the results: what kind of conclusions can be drawn from the calculated data.

The students of fourth and fifth years are obliged to choose two elective subjects in each semester. The large group of elective subjects include subjects closely related to the chosen branch of the student but many of them give some general knowledge in a field of chemistry. Our department presently offers three elective subjects: The Principles of Theoretical Inorganic Chemistry, Inorganic Polymers and Organo-metallic Compounds, Corrosion Protection. The lectures of an elective subject attract a smaller number of students due to the fact that the total number of the announced subjects is over 200.

In a consequence of the fact that the subject 'General and Inorganic Chemistry' is the first chemical subject for all the students, we have the possibility to attract some of the talented and diligent students to participate in the scientific activity of students under the leadership of the teachers of our department, during the years traditionally our students have won first prizes in scientific conferences of students organized at the faculty or even in national conferences. The most distinguished students of our faculty can continue their studies in the second level of tuition according to an individual program of the course if they present an application together with a teacher of the faculty and the Faculty Council makes decision on the bases of the academic record of the student and the plan for the research program. In the last ten years we have had four students working in our department with individual study program.

In each year 2-3 students prepare their thesis in the department for getting the production engineer grade and the same number of students make their project work to become chemical engineer in the second level of the tuition program.

It has to be mentioned that like at the other faculties of the Technical University of Budapest, at the Chemical Engineering Faculty English language course is in progress for foreign students. All the mandatory subjects assigned to our department in the Hungarian language course are lectured in English, and the same can be said concerning the related seminars and laboratory practices. Since 3 years we have given the opportunity for the Hungarian students to participate in the seminars on chemical calculations in English language and the students may attend some or all the

lectures of 'General and Inorganic Chemistry' for foreign students (free of charge).

Our educational activity outlined in this communication is run by 15 teachers and 4 researchers of the department. We do not consider the teaching as supplying the students with a constant and finally closed store of knowledge, doing a routine work but we continuously try to introduce new informations and we speculate how our teaching methods can be developed, made more effective. Thus, we have a wide spectrum of plans on our future tuition activity, in accordance with the comprehensive conception of the Chemical Engineering Faculty.

Address:

József RÉFFY
Department of Inorganic Chemistry
Technical University of Budapest
H-1521 Budapest
Hungary