

# TEACHING OF CHEMISTRY IN THE ELEMENTARY SCHOOL

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## REQUIREMENTS FOR ELEMENTARY SCHOOL CHEMISTRY

This report is based upon observations made in the experimental teaching of chemistry at the 6th, 7th, and 8th grade levels. This program of research was begun in 1952 at the Lake Villa Community Consolidated School, Lake Villa, Illinois. Each class, composed of 10 to 15 students, met at 8 a.m., three days a week, one hour before the rest of the school convened. Various aspects of the subject as usually taught in a first-year course in high school or college were tried to learn which of them were readily grasped and which were not. Since, admittedly, chemistry is a difficult subject for high-school or even freshmen college students, it seemed that a different method of presenting it had to be found. Such a course, to be suitable for grade school, had to be adaptable to groups of from 30 to 40 students, without the benefit of laboratory facilities, and so well organized that it could be taught by a teacher lacking extensive formal training or experience in its presentation.

These requirements might at first seem to have been insurmountable, but two considerations encouraged the undertaking: 1) There is a natural interest in chemistry at this age. Commercial interests have profited from this curiosity by furnishing chemistry sets with instructions

on how to perform a number of interesting but unrelated experiments. The teaching profession has generally responded, not by teaching chemistry, but by telling the students *about* chemistry without supplementing this information with experiments. This method is about as satisfying to students as a choice steak would be to a starving man if he were given nothing more substantial than a vivid description of it. It would seem axiomatic that if a student is intensely interested in a subject, regardless of his age, there must be some way to teach it to him. 2) The second consideration concerns the challenge imposed upon us by Russia. If Russians can introduce chemistry at the third-grade level with advantageous results, certainly American children can be taught chemistry before their junior or senior year in high school. Of course, we are handicapped by having to teach *all* of our children, as contrasted to the Russian system which concentrates its efforts on the gifted and talented. This is not an insurmountable obstacle, however. Chemistry is not a subject to be taught in the grades as a full year's course, but rather in units of perhaps six weeks each. There are many other important subjects that must also be taught at this time. On the completion of these units in each of the last three years in the elementary school, those students showing unusual promise could then,

on the recommendation of the grade school, and possibly on the basis of competitive examination, be selected for early and progressive training in high school. In this way, the less gifted students could still meet their university entrance requirements by taking chemistry at the usual time, and the talented students would be given the opportunity they deserve.

Grayslake High School in Grayslake, Illinois, and Antioch Township High School in Antioch, Illinois, are already adjusting their curricula to accept such students and are preparing special courses for them. This year, on the freshman level, biology is being taught to these students in place of general science, and eligible sophomores have been allowed to enroll in chemistry. In the next few years courses in analytical chemistry and organic chemistry will be provided for interested and qualified students in their junior and senior years. If this program continues to progress as planned, students benefiting from it should have an experience in chemistry comparing favorably with that offered by the Russian system.

### THREE UNITS FOR MEETING THE REQUIREMENTS

As a result of this research, we have developed a series of three six-week units of study to be taught in a specific order in the 6th, 7th and 8th grades. Each of these units features simple experiments to demonstrate the principles discussed and to emphasize the qualitative aspects of the subject, for we realized early in this work that the children were primarily interested in learning by

seeing and doing. The quantitative work is directed chiefly at teaching the students how to write correct formulas and balance equations. The current theory of the structure of matter is reserved for the last phase of study, for it seems only logical that an attempted theoretical explanation or application of facts is interesting and profitable to students only after the facts themselves are thoroughly known.

*Unit 1.*—No other instrument yet developed is so useful in presenting the facts of chemistry as the Periodic Table of the Elements. Historically, it created order out of chaos in the subject and made of chemistry a science. Accordingly, it is used as the basis of all the units and is carefully taught as the first lesson. Any student taking Unit 2 or 3 without having had the first unit would have to study the first lesson in this unit. Only the elements usually considered in a first-year course of study are included, and they are presented to the student in a unique manner. For example, in Figure 1, hydrogen is called the "Ancestor" of the families of elements. The family of rare gases is called the "Royal" family for they are "standoffish" and will not associate with or combine with any of the "Commoners" in our table and are therefore designated the "O" family as well. The seven regular families, just like human families, have "parents" and two kinds of "children." The "cousins" are closely associated with the "children" of the seven families.

The elements are classified (Fig. 2) as follows: 1) metals; 2) non-

metals; and 3) hydrogen, a unique element that looks like the nonmetals but chemically acts like the metals. The properties of these classes of elements are enumerated and demonstrated. The students are already familiar with the properties of the metals and readily learn to classify them and to distinguish between their physical and chemical properties. They are then introduced to those nonmetals with which they are not familiar. Nonmetals too are described as having properties more or less in common: 1) individual personality; 2) allotropy or the property of exhibiting more than one personality; and 3) their integral relation to the gaseous state. This classification is original and helpful as a basis of reasoning in the course. The unit is completed with a lesson on identifying the elements by bead tests, flame tests, and spectroscopic analysis.

*Unit 2.*—Compounds. The following simple classification of compounds is based upon the Periodic Table and our classification of the elements: 1) hydrogen-nonmetal compounds; 2) metal-nonmetal compounds; and 3) nonmetal-nonmetal compounds (Fig. 2). The law of definite composition is explained, and compounds are contrasted with mixtures. This leads naturally to a study of ionic solutions, valences, and solubilities of compounds. A ceramic plate developed for the course is used for drop testing. These plates are replicas of the Periodic Table. Each student places a drop of each of the metal ions in its appropriate depression in the plate and then tests each with a drop of a selected reagent—sulfide, halide, chro-

mate, etc. This very quickly acquaints the students with hundreds of salts, their colors, solubilities, and other characteristics. This unit also includes the properties of acids and bases and the nature of neutralization and hydrolysis reactions.

*Unit 3.*—In the first section of this unit elements are recovered from their compounds, some of which have been prepared in Unit 2 from the elements studied in Unit 1. In this way the principle of the indestructibility of matter is taught. The second section introduces the student to some simple organic compounds. Group preparation of alcohol and soap and individual preparation of small amounts of sweet smelling esters constitute the experiments. The unit closes with a lesson on the current theory of the structure of matter. This is readily taught to the students who are now thoroughly familiar with the Periodic Table.

#### RESULTS OF INITIAL TRIALS WITH THE UNITS

Three schools have seriously attempted the teaching of the first unit this year. One of these schools has gone on into the second unit because of the success of the first. The third unit has not yet had its "trial by fire." Materials for use in the units have been assembled into convenient time-saving teachers' kits. The results given below represent the combined observations of the three teachers who have pioneered these units: Harrison Brown of the Antioch Community Consolidated Grade School in Antioch; Karl H. Ohlen-dorf of the Lake Villa Community Consolidated Grade School in Lake





Villa; and Mrs. Elaine Helke of the Oak Terrace Grade School in Highwood. All schools are in Lake County, Illinois.

1. Chemistry was found to be definitely teachable in the units used. The children showed amazing ability to grasp scientific concepts, terms and facts. One teacher said that any teacher with a certificate could teach the units. Another expressed a belief that Unit 1 could be taught in the third grade.

2. Unsuspected talents and interests were discovered. One problem boy suddenly became a regular attendant at class and an active participant in discussions. Another student, one who apparently could not read with understanding, had no trouble reading chemistry, a subject in which he showed a definite interest.

3. The fun of learning chemistry stimulated interest and desire to learn in other fields.

4. The natural curiosity of students of this age was fed and stimulated often to an intense enthusiasm. Many students surprised the teacher by volunteering information obtained by outside reading. Noting this, one teacher offered extra credit for special reports. One student furnished four such reports during the course of the six weeks unit.

5. The fear of chemistry, as a difficult subject, in students and teachers was definitely dispelled. In written evaluations asked of the students at the end of the course, most expressed a desire to go on with the study of chemistry. All three teach-

ers admitted their own fears and misgivings on beginning the units, but all expressed confidence at the end of the course. One teacher felt that this basic fear in the average teacher would be the greatest stumbling block in putting the units into general use.

### CONCLUSIONS

Enthusiasm for lifetime careers in science begins at a very early age. Forty of this year's winners of the Westinghouse Science Talent Search, at an age of 3 to 15 years, developed the desire to be scientists, with the average number charted between the ages of 6 and 10. In view of this, and considering our national need for developing scientists, the teaching profession has a serious responsibility to introduce *all* scientific subjects in the elementary school.

Based upon the assumption that it is a difficult subject, chemistry is not only avoided in the grade school but is not introduced in high school until the junior or senior year. Many high schools, 50% of them in this country, do not teach chemistry at all. A six-year program of research to find a method of introducing chemistry in the elementary school has resulted in the preparation of three six-week units. These units are designed not only to be taught to children 10 to 12 years of age, but by teachers not trained in the subject. Three elementary schools in Lake County have reported highly satisfactory results with these units after one year of experimentation.