

ducted by the teacher. A written test was given on which the grades of the class compared favorably with previous test grades of the same class. A laboratory test was given by using the materials studied in projects as unknowns for identification. Only one pupil in the class failed to identify his unknown.

Another advantage of the method is that it gives the pupil working intensively in a small field a chance to learn to use the reference library. In fact a good department library is a necessity in doing this work. Such books as Thorp's *Industrial Chemistry*, Molinari's *General and Industrial Chemistry*, Leach's *Food Inspection and Analysis* were in constant use in the completion of the projects. Brownlee's *Chemistry of Common Things* and Weeds' *Chemistry in the Home* were good starting points as they connected the things of the laboratory with the things of every-day life.

From the result of this experiment the writer feels that the project method has decided advantages, and that its disadvantages can be lessened and eliminated as its application is studied and its technique improved. When conditions such as large classes or insufficient time in the laboratory prevent conducting the class wholly in this way, a list of projects supplementary to the regular work could be prepared. This would afford extra work for the bright pupil who finds the laboratory pace set by the average pupil too slow. It would give all pupils a chance to work on special problems and to connect the material of the course with their individual outside interests. Starting in this way many teachers could experiment in project-teaching, and by contributing their results, help in extending the scope and perfecting the technique of project-teaching in chemistry.

TEACHING OF THE THEORY OF ELECTROLYTIC DISSOCIATION IN HIGH SCHOOL CHEMISTRY.

By WM. H. BROWN,

Principal of High School, Amherst, Mass.

Belief that a good understanding of the theory of electrolytic dissociation helps the student of chemistry to a better grasp on the subject has led the writer to put considerable time on that topic in his classes. The necessity of a somewhat broad knowledge of chemical reactions for the proper development and appreciation of the theory makes it seem best to postpone its consideration until the course is well advanced, about in the fourteenth week.

I. Remote Preparation.

In the previous study of the course the students have become acquainted with many chemical reactions which are ionic, although no mention of the term has been made. They have observed, however, that there are certain groups of atoms which stay together in reactions, such as the sulphate and hydroxyl groups. Desire for an explanation of this behavior has been aroused in the minds of the students. The electrolytic preparation of hydrogen, oxygen, and chlorine, as well as the action of electrolytic cells of various kinds, also call for an explanation.

II. Direct Preparation.

First Day. The material included in the remote preparation is reviewed. The difference between the conducting powers of solutions of acids, bases, and salts, and of substances such as sugar and glycerine is demonstrated—the conductivity being measured relatively by the brightness of an electric light bulb connected with the lighting circuit through the solution. The difference between the conductivity of solid and solution is also demonstrated. In the explanation of these phenomena the class has a problem, an insurmountable problem for them if the teacher does not guide them carefully. The problem for the next day is stated, the mechanics of the experiment explained, and new terms such as gram molecule, electrolyte, and non-electrolyte defined.

Second Day. A double period is available for this day, which is devoted to individual laboratory work. The object is to find out the relation between the depression of the freezing point of a solution and its molar concentration, using only non-electrolytes. It must be admitted here that the class can see no connection between this problem and the big problem referred to on the previous day, but in view of the fact that it has taken the greatest scientific minds of the world decades to evolve this theory the high school pupil cannot be expected to march unaided through the logical steps to its statement. The procedure of the experiment is simple. Molar and twice molar solutions of sugar and glycerine are used, and their freezing points obtained by cooling a test tube containing the solution to the depth of about two inches in a beaker full of a freezing mixture of ice and salt. Supercooling can be prevented by introducing a tiny crystal of ice. The temperature is taken on an ordinary chemical thermometer, the range ordinarily reported by members of the class being from -1.5°C to -2°C for the molar solutions and

from -3°C to -3.5°C for the twice molar solutions. In the few minutes of discussion that follow the laboratory work the results of the class are tabulated on the board. This serves to uncover and eliminate any readings which are far from the median and to furnish averages on which class discussion can be based with some degree of accuracy. When considering the results obtained with one substance the first statement invariably made by the class is that the depression is proportional to the weight dissolved per liter. Calling attention to the results obtained with the other substance shows that this does not hold between two different substances. With a little guidance the class arrives at the statement that the depression is proportional to the number of molecules dissolved per liter or per unit volume.

Third Day. The object of this day's laboratory work is to find out how the depression for molar solutions of sodium chloride and barium chloride (electrolytes) compare with the depression for a molar solution of sugar. The same procedure is followed as on the previous day. The results are usually from -3°C to -3.5°C for the sodium chloride and from -4.5°C to -5°C for the barium chloride. The truth established the day before has apparently been discredited. Again the results are tabulated on the board and it is pointed out that the depression in each case is a multiple of the depression obtained for the molar sugar solution the day before. The work of the day ends at this point and the class is dismissed with instructions to bring in on the next day an explanation of these abnormal depressions. Reference is made to the text.

Fourth Day. The work on freezing points is reviewed, and step by step the supposition is developed that the molecule of a salt when dissolved in water breaks up into two or more particles (which we may call ions) which have the same effect as molecules in the lowering of the freezing point. Assuming that ions carry electric charges, the logic of this supposition can be shown in the case of electrolysis, the electrolytic action of cells, and the non-conductivity of solid sodium chloride and of substances such as sugar (non-electrolytes). The idea is now illustrated by writing of equations showing the ionization of a compound. Attention is called to the reversible character of the reaction. Various equations which have been met previously are now written as ionic equations. The scheme used by Stieglitz, in his "Qualitative Chemical Analysis," is

introduced here and practice is given in the writing of equations in this way.

At some time before leaving the topic the teacher points out that, after all, this is only a theory, a guess, as to what actually takes place, and the objections to the theory should be made known. Some of these are quoted in "Qualitative Chemical Analysis," referred to above, and may also be found in Kahlenberg's "Outlines of Chemistry." The fact is emphasized that, nevertheless, the theory is very generally accepted. Referring to the objections, the teacher points out that it is well to respect the opinions of others, even though we do not accept them; mentioning some of the popularly discredited ideas which have eventually been proven true. The value to progress of unproven theory is pointed out.

III. Later Application.

For several weeks all the equations encountered which are ionic are written as suggested above in order to show the reactions between ions and to make clear the reason for a reaction going to an end. Hydrolysis of salts is also explained in this way. Although it is not considered necessary to write all double decompositions and other ionic reactions in the ionic form, that method is occasionally brought in as a reminder of this great underlying idea. As a result of this emphasis the writer believes that he sees in his pupils a better understanding of chemical phenomena and more power in the working out of equations in new situations.

THE UTILITY OF MINERALOGY IN ELEMENTARY CHEMISTRY.

BY J. NORMAN TAYLOR,

Washington Preparatory School, Y. M. C. A., Washington, D. C.

There is a realization among teachers of chemistry that the science is best taught from the laboratory standpoint. This is the natural way. One of the primary instincts of the human race is that of curiosity and in satisfying this trait a logical way is opened for the unfoldment of knowledge. Theory, being based on fact, is best assimilated by the utilization of concrete examples and in no other of the sciences is this more evidenced than in chemistry. Interest in chemistry among secondary school students is always awakened by the selection of laboratory experiments of a nature which appeal to the students' every-day