LABORATORY OUTLINE OF GENERAL CHEMISTRY: FROM ELECTROLYTIC DISSOCIATION TO THE METALS AND THEIR COMPOUNDS, VOL. II

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Laboratory Outline
of General Chemistry

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VOLUME II

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These experiments are taken primarily from Prof. Alexander Smith's "Laboratory Outline of General Chemistry" and all references (marked with R) are made to his new book, "Introduction to General Inorganic Chemistry."

—William J. Hale

GEORGE A. SNYDER
Printer & Publisher
Dayton, Ohio

CHAPTER X.

IONIC CHEMICAL ACTIONS. INTERACTIONS OF ACIDS, BASES AND SALTS.

1. IONIZATION. How do we ascertain experimentally whether a substance is ionized in solution or not and learn the extent of the ionization [R. 310]? The degrees to which aqueous solutions of many substances are ionized are given in a table in the Appendix. Constant reference to this table will be necessary in interpreting the observations in this and succeeding chapters.

Obtain [Temp. order] a pair of electrolytic cells [Fig. 11], and observe that one cell is partially filled with dilute sulphuric acid. When the cells are connected in series with a battery, evolution of gas in this cell will indicate that the material placed in the second cell is a conductor, and that the circuit is therefore complete. If, on the other hand, the material in the second cell is a non-conductor, or at all events a very bad conductor, no evolution of gas will be observed in the first cell. When the substance placed in the second cell is a solution, what conclusion may be drawn in regard to the condition of the dissolved body? [R. 310].

Half fill the second cell with the substances named below in turn. See very particularly that the electrodes in each cell are on opposite sides of the glass partition, connect with the battery, and observe the effect in the first cell. When the same experiment has been shown in the lecture-room the result may be recorded here and the experiment omitted. Wash the cell and the electrodes carefully and dry well after each trial.

NOTE 14.—Nomenclature: In order that the nomenclature of the ions may be made as simple as possible, the following system has been adopted [R. 322]. The names of the cations are derived by adding the termination —*ion* to the stem of the element or radical, hydrogen, however, is called simply *hydrion*. When an element forms several ions of different valences, then the Greek prefix indicating the valence is applied. The anions derived from those substances whose names terminate in "*ous*" or "*ite*" receive instead the termination "*osion*," while those which originally terminated in "*ic*" or "*ate*" receive the termination "*anion*": the carbonate ion is usually shortened to *carbanion*. The elements or radicals retain in all cases whatever prefixes they originally had.

Solutions of ionogens in water are in fact mixtures of several physical components [R. 334] while in water alone there are three components, namely—the two ions and the undissociated

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molecule *(water in equilibrium with hydrion and hydroxidion).* The degree of this dissociation is found by conductivity determinations to be exceedingly small [R. 331], and hence the prevailing component is the undissociated molecule. In many cases the components theoretically possible can be present only to the slightest extent in a solution. Knowledge of these facts may be gained by reference to the dissociation table in the Appendix.

a. Distilled water.

b. Diluted aqueous solution of sodium hydroxide.

c. Diluted aqueous solution of hydrochloric acid.

d. Dry sodium chloride.

e. Diluted aqueous solution of sodium chloride.

f. Aqueous solution of sugar.

g. Toluene.

h. Solution of dry hydrogen chloride in toluene. [Obtain this from the side-shelf and return to the original bottle after the experiment].

i. Concentrated acetic acid. [Obtain from side-shelf and return to the original bottle after the experiment].

j. Diluted aqueous solution of acetic acid.

2. BASES AND ACIDS: PROPERTIES OF HYDROXIDION AND HYDRION.

a. Examine distilled water in respect to (a) taste, (b) behavior with litmus, (c) conductivity (cf. 1, *a*).

b. Examine toluene in respect to (a) behavior with litmus, (b) conductivity (cf. 1, *g*).

c. Examine an aqueous solution of hydrochloric acid in respect to (a) taste, (b) behavior with litmus (c) conductivity (cf. 1, *c*). (d) action on a piece of zinc, (e) action on a piece of marble. Acids in aqueous solution possess these properties in general. What ion common to all must then give these properties to their aqueous solutions? Express the components present in this solution in two sets.

d. Examine a sample of the solution of hydrogen chloride in toluene in respect to (a) conductivity (cf. 1, *h*), (b) action on a dried granule of zinc, and (c) action on a dried piece of marble. Be careful to use perfectly dry vessels in these experiments. What ion identified in *c* is here lacking? What difference in action has the water from that of toluene?

e. Dissolve a very small piece of sodium hydroxide in a test-tube full of water and examine the solution in respect to (a) taste, (b) behavior with litmus, and (c) conductivity (cf. 1, *b*). Bases are hydroxides of metals or metallic radicals and their aqueous solutions possess, to a greater or less extent, the properties just indicated. What component common to all must therefore have these properties? Write the five components present in a solution of sodium hydroxide in water.

f. The action of conc. sulphuric acid on zinc (Chap. IV, 2, *d*) and that of the dilute acid upon the same metal (Chap. IV., 2 *c*) indicated the difference in the properties of the two acids. Ascertain whether the action of (a) conc. acetic acid and (b) dilute acetic acid upon this metal, or any other metal e. g., magnesium, is in any way analogous thereto. To what inference does this lead in regard to the nature of the concentrated acid (cf. 1, *i*) and also of the dilute acid (cf. 1, *j*)? Why is the action so much more marked in the case of conc. and dilute sulphuric acid than with acetic acid. (See table in Appendix).

3. IONIC CHEMICAL CHANGES: I. NEUTRALIZATION. (Two students working together).

When solutions of two ionogens are mixed, a greater dilution for each ionogen results, but no appreciable change will be observed unless, by a crosswise combination between ions of opposite charge, the formation of a less ionized substance becomes possible [R. 337]. Pure water, for example, is only in the slightest degree ionized (cf. 1). If then a mixture of a solution of an ionogen supplying hydroxidions be made with one supplying hydrions, a most rapid and marked change would occur, whereby the slightly dissociated molecule—water—would form at the expense of these two classes of ions.

Dissolve about 5 g. of sodium hydroxide in 50 c.c. of distilled water and pour the clear solution into a burette. Mix in a small beaker about 10 c.c. of conc. hydrochloric acid with about 50 c.c. of distilled water and pour this into a second burette. Now, into a small beaker or flask run 15 c.c. of the acid solution from the second burette and then add to it two drops of phenolphthalein solution. Place the vessel under the first burette and run in the alkali very slowly at first and finally, when the color begins to spread throughout the liquid before vanishing, drop by drop, until the entire solution acquires the faintest perceptible pink tinge (with hydroxyl ions phenolphthalein gives a red color, with hydrogen ions it remains colorless). If the "end-point" (denoted by the appearance of the faint color tinge) is overstepped, then enough more of the acid solution must be added to bring back the faint tinge. The walls of the beaker or flask should always be washed down with distilled water before pronouncing the titration at an end (?). Concentrate the solution thus obtained on the sand-bath until a drop removed and cooled shows the appearance of crystals. At this stage promptly remove the dish from the sand-bath and set it aside. When a sufficient quantity of crystals have appeared, filter them off from the mother liquor and allow them to dry upon filter paper in a warm place. Examine them with respect to (a) form, (b) taste, (c) exposure to moist air, (d) action of a solution upon litmus and (e) conductivity of aqueous solution (cf. 1, *e*). Construct a table comparing the substance in these respects with the materials from which it was made. Compare the substance with common salt upon the side-shelf.

Draw up a table consisting on the one hand of the physical components present in the acid solution, and on the other hand of those in the alkaline solution. Ascertain, by reference to the dissociation table in the Appendix, the relative proportion in which these components are present in the above solutions, and again the tendencies those of opposite charges will have to form new substances (as inferred from the dissociation of these new substances that are less ionized). To what extent can these unions go [R. 339]? Why does the present reaction run to completion?

Express the change, here known as neutralization (why?), by means of symbols, using only the symbols that are concerned in this process. How may we define neutralization in terms of the ionic theory? What term is applied to the solid product obtained above as the result of neutralization?

NOTE 15.—From the theory of neutralization [R. 351] we observe that each and every hydrion is removed by its union with an hydroxidion of a base. This gives us at once a simple means of determining the amount of base or acid present in an unknown solution, if we have at hand a solution of known concentration to titrate or balance against it. Standard solutions have been calculated on the basis of their containing but one hydrogen (1.01 g.) or one hydroxyl (17.01 g.) to the liter. Thus 40.06 g. of sodium hydroxide must be contained in one liter of its solution in order that the solution may be normal, *i. e.*, contain 17.01 g. hydroxyl. A solution of any fractional part of this weight to the liter would consequently be denoted by that same fraction of normality.

What was the (approximate) normality of the sodium hydroxide solution used in the above experiment? Calculate, from the ratio of the hydrochloric acid solution required for neutralization, the normality of the acid solution, and also the grams of hydrogen chloride present in a liter.

4. PARTIAL NEUTRALIZATION.

Fill a bottle with a potassium hydroxide solution (obtained from the side-shelf—the solution is about 5-normal). Slowly add, with constant stirring, about 15 c.c. of conc. sulphuric acid to about 35 c.c. of distilled water contained in a beaker surrounded with cold water. When the solution has reached the room temperature pour it into the second burette. Ascertain by titration as in 3 (q. v.) what volume of the alkaline solution will be required to exactly neutralize 5 c.c. of the acid solution. Pour the neutral solution thus obtained into an evaporating dish and concentrate it upon a sand-bath till its volume is about 10 c.c., then remove the dish from the bath and set aside to cool. Filter off the crystals that appear and dry them upon filter paper.

To a second portion of the acid solution twice the volume previously used (*i. e.*, 10 c.c.) add exactly the same volume of the alkali above used; now evaporate the solution to a volume of 5 or 6 c.c. and set aside to cool. Filter off the crystals formed and dry as before.

Compare the two lots of crystals as regards (a) form, (b) taste, (c) reaction of solution with litmus. Confirm by examining specimens of the same substances from the side-shelf.

From a study of sulphuric acid we observe that for its complete neutralization two hydrions must be removed from each molecule that goes into solution. Such was exemplified in the first titration above. In the second, however, the acid was double the amount that the measured quantity of alkali could neutralize, *i. e.*, the hydroxidions supplied could only remove one-half of the available hydrions, consequently the remaining portion of hydrions will be associated with the sulphanion as before. In other words we shall have a salt that possesses ionizable hydrogen formed by the partial neutralization of an acid *i. e.*, what is commonly called an "acid salt."

Express by an equation the first step of the dissociation of sulphuric acid in solution. Express also the dissociation of the "acid salt" in the process of its further neutralization by a base.

The molecular weight of sulphuric acid is 98. How many grams of pure acid would be contained in a liter of its normal solution?

5. IONIC CHEMICAL CHANGES. II. SALTS IN SOLUTION.

The application of the Law of Mass Action to ionic equilibrium.

a. The dissociation of salts in solution was demonstrated in the study of common salt (cf. 1, *d*, *e*). Are all salts in solution ionogens? From observations on the conductivities exhibited by conc. and dilute acids (cf. 1, *i*, *j*) what do you infer regarding the effect of increased dilution upon solutions of ionogens [R. 335]? How does the number of ions per unit volume, *i. e.*, the concentration, vary with dilution? On increasing the dilution of a solution of hydrochloric acid the increase in chloridions gives no color effect to the liquid which contains the colorless hydrions, and we therefore assume the chloridion also to be colorless. Examine a solution of sodium hydroxide or sodium chloride and determine whether the natrion imparts any color to its dilute solutions. Now take a minute amount of well-dried cupric chloride (about 0.2 g) in a dry test tube. Observe the color of the undissociated cupric chloride. Add 2 or 3 drops of water and shake. What color appears? Gradually add more water with constant shaking until all is dissolved. Continue in this wise until the change in color is complete. To what is the color due. Compare the color with that of a dilute solution and interpret the result (?) Should a conc. solution of sodium