

The Gravitational Separation of Ions in Solution

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This experiment attempted to show that ions in solution will separate to a certain extent because of the difference in their masses. It was found that a potential was present between the extremes of the solution used and that the solution acted as a capacitor. Difficulties in measuring the potential are discussed in this report, along with the reasons and concluding beliefs concerning the properties of the solution, derived from experimentation and research. The experiments that were performed in order to prove this placed emphasis on qualitative rather than quantitative data.

INTRODUCTION

"It is of interest in regard to the theory of ionization that an electric potential difference exists between the two ends of a solution of a salt such as lithium iodide (composed of a heavy ion and a light ion) in the earth's gravitational field or a centrifugal field," according to Pauling (1953).

The purpose of this investigation was to confirm the observation made by Pauling and to determine the reason for the potential's existence. Since Pauling did not emphasize the reason for the potential's existence, the only hypothesis which seemed practical and which agreed with the observation was formulated: the ions separated in solution because of the difference in their gravitational masses.

A saturated solution of barium hydroxide was used in the experimentation. Each barium ion was about eight times as massive as an hydroxyl ion or a water molecule. After the potential's existence has been confirmed and an attempt had been made to measure it, it was found that the barium ions had concentrated somewhat at the bottom of the solution, while the hydroxyl ions apparently dispersed in the solution.

MATERIALS

Stansi galvanometer, cat. no. D-251OP, sensitivity 500-0-500 microamps

Leeds-Northrup Student's Potentiometer, cat. no. 7645, sensitivity 0.000-1.6 volts

Cenco millivolt meter, cat. no. 82420-1, sensitivity 0-100 millivolts, 2 millivolts per division

Sixteen molar sulfuric acid, two 25ml test tubes

Triplett volt-ohm-mil-ammeter, cat. no. PG 2560

Beckman Zeromatic pH Meter, cat. no. 9600

Miscellaneous: a one liter graduate; one liter of saturated Ba (OH)₂ solution (5.59g/100g H₂O @ 30°C); two electrodes, each consisting of 4.2m of spiraled platinum wire; assorted switches and necessary wires.

EXPERIMENTS AND RESULTS

First, the potential was confirmed. An electrode was placed at each extreme of the solution, as shown on the last page of this report. The galvanometer indicated the presence of a small potential which disappeared within two seconds. It did not reappear until the circuit had been opened and allowed to set for several minutes. The instantaneous potential seemed to be larger the longer the solution stood undisturbed before each

measurement. The direction of deflection of the galvanometer needle indicated a positive ion concentration at the bottom, or else a negative ion concentration near the top electrode. When distilled water was substituted for the solution, no potential appeared.

The second experiment utilized the potentiometer and showed that the solution acted as a capacitor. When a current was introduced into it, the charge was retained and gave a false reading of potential. The potential, therefore, could not be measured in a balanced circuit, which introduces a voltage to the electrodes.

A millivolt meter was used in trying to measure the potential voltage directly. The maximum potential observed was 2mv. In order to accurately measure the potential, a microvolt or low range millivolt meter was needed. Since one was not available, the change in potential as the top electrode was lowered was not observed.

The ohmmeter showed that the resistance of the solution changed as the direction of the applied current was reversed. The path of least resistance for electrons proved, from repeated measurements, to be from the top to the bottom of the solution. This path is from a relatively greater negative ion concentration to a greater positive ion concentration. The lowest resistance in the opposite direction was about four hundred ohms greater. The resistance test also confirmed that the solution acted as a capacitor since the resistance in each direction increased to approximately twenty thousand ohms within ten seconds.

The last two experiments confirmed the concentration of barium ions at the bottom and the total dispersion of the hydroxyl ions. A pH meter indicated that the pOH of samples taken from the top and the bottom of the solution were the same, 12.4. Concentrated sulfuric acid was added to more samples which, by precipitating nearly insoluble barium sulfate, indicated that the concentration of barium ions at the top was about two-thirds the concentration at the bottom.

DISCUSSION OF RESULTS

The hydroxyl ions seemed to have remained dispersed for two reasons. First, they were attracted to the barium ions and pulled down with them. Also, the hydroxyl radical is nearly equal in mass to the water molecule, which supposedly remains fairly constant in concentration at all levels in the solution.

The barium ions, however, were massive enough to be affected by gravity. Under centrifugation, the barium ions would probably become much more concentrated at the bottom.

It was presumed that every solution containing heavy and light ions of opposite charges will demonstrate capacitance between its top and bottom if the differences in their masses is great enough. No reason can be seen for barium hydroxide to be an exception.

A basic instead of a salt solution was used in the experimentation. It is not believed that this changed the results in any way. Pauling used lithium iodide as an example; but it is insoluble in cold water and decomposes in hot water to form, as one product, lithium hydroxide. Therefore, the solution of lithium iodide would also have been basic.

It is my firm belief that there was a steady potential present which was due to the separation of ions by their gravitational mass differences. The potential appeared instantaneous because the increase in resistance of the solution during potential measurement opened the circuit. All of the potential measurements that were taken were therefore inaccurate and have not been included in this paper.

BIBLIOGRAPHY

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