DISSERTATION. OSMOTIC PRESSURE MEASUREMENTS OF LEVULOSE SOLUTIONS AT THIRTY DEGREES

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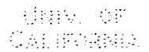# DISSERTATION. OSMOTIC PRESSURE MEASUREMENTS OF LEVULOSE SOLUTIONS AT THIRTY DEGREES

OSMOTIC PRESSURE MEASUREMENTS OF LEVULOSE SOLUTIONS AT THIRTY DEGREES

DISSERTATION

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requirement for the Degree of Doctor
of Philosophy.

By
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I. ACKNOWLEDGMENT.

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The author is especially grateful to Prof. Morse, at whose suggestion and under whose guidance this investigation was undertaken and carried out.

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THE OSMOTIC PRESSURE MEASURMENTS OF LEVULOSE SOLUTIONS AT THIRTY DEGREES

II. LEVULOSE SOLUTIONS.

The levulose, which was used in this investigation was obtained in Germany. The ~~se~~preliminary purification in which the penta-acetate was made, giving the pure sugar upon hydrolysis, was performed by Dr. C. S. Hudson, of the Bureau of Chemistry at Washington, D. C. The author wishes to acknowledge his obligation to Dr. Hudson and his co-workers for this valuable material.

There remained in the sugar some traces of acetic acid. Our solute was freed from the traces of acetic acid by the following method, depending upon the fact that levulose is practically insoluble in cold absolute alcohol.

One hundred grams of the once recrystallized sugar were dissolved in fifty cubic centimeters of 75% alcohol which had been previously warmed on a steam bath. Seventy-five cubic centimeters of absolute alcohol were added to this solution. It was necessary, in some cases, to add a little animal charcoal and a few cubic centimeters of washed alumina to remove a slight turbidity. After filtering the mixture, twenty-five cubic centimeters of absolute alcohol were added to the clear filtrate. Upon "seeding" the solution, the sugar was precipitated. The crystallization was carried on in a dessicator with frequent stirring. The yield was about 50% of the original material used and the specific rotation was found to be 92°.0, the same value as the one assigned to pure levulose by the Bureau of Chemistry at Washington.

Solutions of levulose are peculiar in that they exhibit a change in specific rotation with change in temperature. A solution which is taken from a cell after having given

a measurement, is examined in a saccharimeter to determine whether or not it has undergone a change in concentration. It was found necessary, because of this change in rotation with change in temperature, to retain a sample of the original solution for the purpose of comparing its rotation, under the same conditions of temperature, with the rotation of the solution which was taken from the cell.

All solutions were made by dissolving a gram molecular weight of the sugar or a decimal part of the same in one thousand grams of water. This weight normal system of making up solutions is used in preference to the volume normal method for the following reasons:[1]

A volume normal solution, made by dissolving a gram molecular weight of the substance, or a decimal part of the same, in water and diluting to one litre is correct for merely analytical purposes. It is "both disadvantageous and illogical whenever any phenomenon is to be studied in which the influence of the solvent upon the solute is involved." "In cases of the latter kind, the true concentration of the solution is determined by the numerical ratio of the molecules of the solute to those of the solvent, rather than by the number of solute molecules in a given space."[2]

Difficulties are encountered when an attempt is made to make up a less concentrated solution by diluting a more concentrated one. For example, "Suppose a 0.1 volume normal solution of cane sugar to be made up by diluting 100 cubic centimeters of a normal solution to 1000 cubic centimeters. With respect to the relative numbers of solute molecules contained in equal volumes, the new solution is one-tenth as concentrated as that from which it was made, but with respect to the ratio of solute to solvent molecules, namely: 1:44.1 and 1:544.1, the concentration of the diluted solution is not 0.1 but 0.081 normal.[3]

1 For further discussion of the advantages of the weight normal system, reference is made to the Monograph by Prof. H. N. Morse, Carnegie Publication, No. 198, Chap. V.

2 Ibid., Chap. V., p. 100.

3 Ibid., p. 100.

The numerical ratio of solute to solvent molecules in a cane sugar volume normal solution at 30 degrees is about 1:44.1. At the same temperature, the numerical ratio of solute to solvent molecules in a volume normal solution of glucose is 1:49.2. Thus we see that the cane sugar solution is 11.5% more concentrated than the glucose solution, although equal volumes of the two solutions contain the same number of solute molecules. This difference would amount to 3.7 atmospheres when stated in terms of osmotic pressure.

The practice of employing the volume of the solvent as the standard for the computation of the gas pressure of the solute made it necessary to make a correction corresponding to the term "b" in the Van der Waals equation for gas pressure. The weight normal system gives us a means of correcting for the volume of the solute molecules. However, the true volume of the solvent in solution cannot be known accurately until the extent of the hydration of the solute is determined at all temperatures.