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Cohesion of Water and of Alcohol

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COHESION OF WATER AND OF ALCOHOL.

BY EDWIN MORRISON.

At the meeting of the Iowa Academy of Sciences in 1904 I read a paper descriptive of a new arrangement of a cohesion of water apparatus adapted to elementary laboratory work. The ease of manipulation, and close agreement of results in ordinary laboratory work led me to the thought of testing the accuracy of the standards of cohesion of water as ordinarily given in text-books and manuals. To my surprise, after a careful search through a number of the best text-books, manuals and works containing physical tables and constants, I found but one result tabulated, that of Gay-Lussac. There may be two reasons why the above author's data has been so universally accepted. First on account of the difficulties attending the use of the ordinary form of apparatus for finding the cohesion of a liquid. Second, the general feeling that the "Old Master Experimenters" left nothing undone or out of account in their experiments.

I need not here give a detailed description of the apparatus, as such a description appears in the 1904 proceedings of the Academy. In brief, the apparatus consists of a circular disk of glass cemented to the base of an accurately turned wooden cone, which has an eyelet screwed into the apex of the cone for suspension from one arm of a scale beam. The experiment consists in adding known weights to the scale pan opposite to the cone until the glass is separated from a vessel of water which is placed immediately under the disk—the disk having been previously pressed down until it was in contact with the water. If the disk when pulled away from the water is wet then we know that a layer of water equal in area to that of the disk has been torn apart by the counterpoise weights. Knowing the area of the disk and the number of grams to separate it we can calculate the number of dynes per centimeter to separate the molecules of water.

Before giving the data and results of the experiment it may perhaps be well to state the precautions taken in the experiment. First, in order to insure that the water used was chemically pure, ordinary laboratory distilled water was redistilled in Jena glass vessels. All the ordinary tests failed to show traces of soluble salts in this water. Second, the disk was thoroughly cleansed by washing in a solution of potassium hydroxide; followed by washing in a solution of potassium dichromate and sulphuric acid; then in alcohol; then the disk was dried in a current of air and washed again in redistilled water. Third, a delicate laboratory scale with a rider weight was used in the experiment.

Data: – Diameter of the disk.

1 Measurement – 106.62 m.m.
2 Measurement—106.98 m.m.
3 Measurement—107.27 m.m.
4 Measurement—106.94 m.m.
5 Measurement—106.54 m.m.
6 Measurement—106.74 m.m.
7 Measurement—107.20 m.m.

Average.. ....106.898 m.m.=10.6898 c.m.

Test No. 1: –The number of grams to separate the disk from water at 4°,C.

Trial 1:—48.725.
Trial 2:—48.730.
Trial 3:—48.725.
Trial 4:—48.733.

Average..48.728.

Test No. 2:—The number of grams to separate the disk from water at 7°,C.

Trial 1:—48.710.
Trial 2:—48.715.
Trial 3:—48.725.
Trial 4:—48.730.

Average..48.720.

Test No. 3:—The number of grams to separate the disk from water at 7°,C.

Trial 1:—48.630.
Trial 2:—48.640.
Trial 3:—48.655.
Trial 4:—48.675.

Average..48.650.

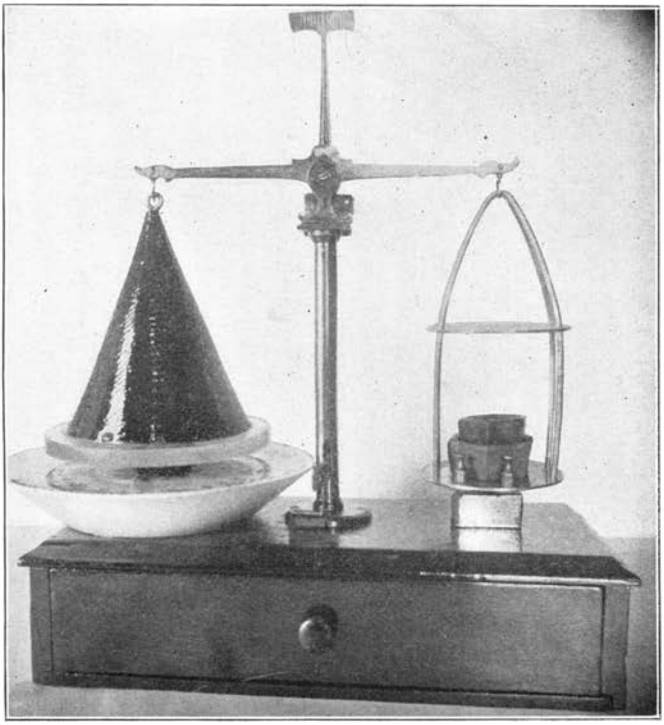
The diameter of the disk being 10.6898 c.m., the radius being 5.3449 c.m., the area is 89.7200 sq. c.m. In the first test given above it required 0.5431 g. to separate one square c.m. of water. In the second, 0.5430 g. and in the third, 0.5421 g. The average of the three tests is 0.5427 g. per square c.m. which is equal to 531.846 dynes per square c.m.

In the same way tests were made upon ninety-five per cent alcohol—specific density 0.8169. In five independent tests the following number of grams were required to separate the disk from the alcohol: 24.63, 24.64, 24.65, 24.65, 24.80; making an average of 24.674 grams. This makes 0.275 g. per square c.m. or 269.500 dynes per square c. m.

In comparing these results with those of Gay-Lussac, we find that he used a disk which was 11.86 c.m. in diameter, and that it required 59.40 g. to separate the disk from water, and 31.08 g. to separate it from alcohol with specific density of 0.8196. This is 526.875 dynes per square c.m. for water, and 275.693 dynes for alcohol. By a careful observation of the above data it will be seen that, up to a certain limit, the cohesion increases upon standing. At present I see but two reasons for this. First, in case of solutions in which a salt is dissolved, evaporation may increase the concentration and thus increase the cohesion. Second, in the use of water or any pure liquid certain substances may be dissolved from the air, thus increasing cohesion. Either of these two explanations leads to the suggestion that cohesion in a liquid is a function of the molecular weight of the dissolved substance, and that cohesion may be used to find the molecular weight of a dissolved substance in the same way as varying the freezing point, or the boiling point in the surface tension method. I have tested this in the case of sodium chloride dissolved in water, and find that with solutions containing a half gram molecule, a gram molecule, and a gram and a half molecule there is a constant ratio in the number of grams to separate the disk from the solution. Similar tests have been made with water solutions of urea and a constant ratio found.

Tests are also being made with naphthalin and urea dissolved in benzene. But these latter experiments could not be completed in time to embody them in this paper, except to show their indicated results. Neither could the constants for the different substances be computed like the constants used in the freezing point and the boiling point methods. Neither could these latter experiments be carried to a degree of completion to enable one to judge whether the method of cohesion will be a practical method for laboratory purposes. There will, perhaps, be two objections to it. First, on account of a considerable quantity of the liquid solution being required in a test, the expense will be greater than in the freezing point and the boiling point methods. Second, evaporation will change the degree of concentration of the solution in the case of volatile liquids. The advantages of the method are the inexpensiveness of the apparatus and the ease of manipulation.

PLATE VIII.



Method of cone suspension in apparatus for finding the cohesion of water.