A New Balancing Drop Method for the Determination of the Density of Heavy Water

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(Received June 28, 1957)

The usual falling drop method[1] for the determination of the density or the deuterium-concentration of heavy water is based upon Stokes' law; the falling velocity of a drop of sample water through a suitable organic liquid is compared with that of standard water. Consequently in this method the size of the drop must be kept strictly constant and the falling velocity must be measured very accurately. Furthermore, the temperature of the working room must be kept as constant as possible in order to secure the equilibration of temperature between the falling drop and the surrounding organic liquid medium. To avoid such troubles we have tried a new method, in which the drop of the sample water is brought to balance in the liquid medium by changing the temperature of the latter as in the case of the float method[2]. Then the density of the sample can easily be known from the temperature dependence of the density of the medium liquid.

The main part of the apparatus is shown in the appended diagram. It consists of an ordinary glass tube about 30 cm. long and 13 mm. wide, the lower end of which is hermetically closed. The tube is provided with a glass stopper S at the upper end and the lower part of the tube is surrounded with a glass jacket J, through which cooling water can be circulated. A suitable organic liquid or a liquid mixture, the density of which is almost equal to that of the sample water, is placed in the tube up to marking M and the whole is immersed in the water of the thermostat down to the level W, while cooling water is circulated through the water jacket J. But as the temperature of the cooling water is kept somewhat lower than that of the thermostat, the density of the liquid column in the tube between H and K is always greater than that of the same

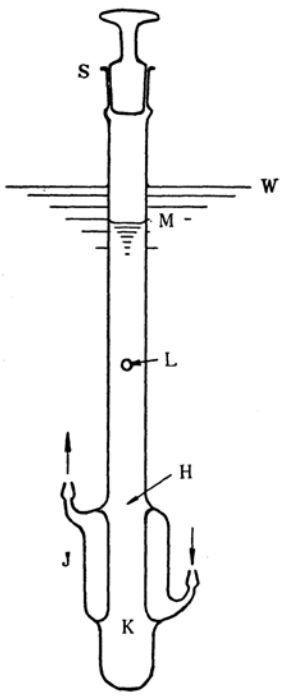

Fig. 1. Apparatus

liquid between M and H. In other words there is a discontinuity in the density of the liquid column at the point H. It is not difficult to choose the temperature of the thermostat in such a way that the density of the liquid column above the point H is less, while that below the point H is greater than that of the sample water, so that the drop of sample water, which has been dropped into the tube, remains at the point H in the liquid column. In this way the drop of water is prevented from falling and adhering to the bottom of the tube.

Now the temperature of the thermostat is carefully lowered and in this way the density of the liquid column in the tube between M and H is gradually increased. Then the drop of the water, which has been allowed to remain at first at the point H, gradually floats up and finally under some adjustment of the temperature it

1) H. G. Barbour and W. F. Hamilton, *Am. J. Physiol.*, **69**, 654 (1924).

2) Such a control of the temperature can be made, because the thermal expansion coefficient of organic liquids is generally greater than that of water.

stops at a certain point (L) in the liquid column between M and H. When this balancing temperature is read off from Beckmann's thermometer immersed in the thermostat, the density of the sample water can easily be known from the temperature dependence of the organic liquid in the tube.

TABLE
EXAMPLES OF THE MEASUREMENTS

Deuterium-concentration atom %: By the pycnometric method	By the present method
0.015*	0.02±0.01**
0.25	0.25±0.01
0.49	0.48±0.01
0.70	0.70±0.02
0.94	0.96±0.01
1.17	1.16±0.01
1.40	1.40±0.01
1.67	1.66±0.01
1.87	1.89±0.02
2.31	2.31±0.00**

* Natural water.
** These samples were used as standards.

Some examples of the determinations are given in the appended table, where the deuterium-concentration of various dilute heavy waters is determined by the present method and the results are compared with those obtained by the ordinary pycnometric method. As an organic liquid, a mixture of 100 parts of chlorobenzene and about 60 parts of xylene was used and the balancing temperature lay at about 35°C.

As will be seen from the table, deuterium-concentration of water between 0—3 atom per cent. can easily be measured by the present method with a relative error of 1%. One of the advantages of the present method over the usual falling drop method is that an accurate micropipette for the making of the drop is unnecessary. An ordinary pipette or a syringe is enough for the making of a drop of water of an arbitrary size for the present method. Furthermore, at the end of an experiment, the water in the liquid column can easily be sucked off by means of a pipette after bringing the drop on the surface of the liquid column by slightly lowering the temperature of the thermostat.

The author wishes to express his gratitude to Professor T. Titani for much help and encouragement in this work.

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