XXXVII.—*On a Simple Method of Estimating Urea in Urine.*

By W. J. RUSSELL, Ph.D., F.R.S., and S. H. WEST, B.A. (Ch. Ch., Oxon).

THE methods for estimating urea which have been suggested by Davy, Knop, and Hüfner, although very simple and easy in the hands of a chemist, have proved to be somewhat too complicated or too expensive for general use. The following is a description of a method similar in principle to those just mentioned, and carried out with an apparatus resembling that described by Hüfner in its general form, but differing from it in being much simpler in construction, less expensive, and more easily repaired if damaged. Our object in fact has been to construct an apparatus inexpensive, and, although simple enough for any one unaccustomed to chemical manipulation to use, still such as to give accurate results. In our process, as in those above alluded to, a strongly alkaline solution of a hypochlorite, or hypobromite, is used, and the amount of urea determined by measuring the volume of nitrogen evolved.

In connection with this decomposition of urea and other nitrogenous bodies by an alkaline hypobromite, there are one or two points of interest which we have noticed in the course of our experiments. On carefully measuring the quantity of nitrogen which was evolved from a known weight of pure urea, we were never able to obtain the theoretical amount; our first experiments were made with the apparatus which we are about to describe, and afterwards, to check these results, we employed the gas apparatus described by one of us on a former occasion (*Chem. Soc. Journ.*, April, 1868). Still, in all cases we found a loss of about 8 per cent. of nitrogen. We have since found that this loss of nitrogen had before been noticed by Leconte, who states that there is also a deficiency of 8 per cent. We should remark, that in all cases this error of 8 per cent. is constant. The amount of gas evolved is the same, whether hypochlorite or hypobromite is used. One obvious objection which might be brought against this process is, that there are in the urine other nitrogenous elements which we should expect to be similarly decomposed by the hypobromite—for example, uric acid, hippuric acid, and creatinine. The amount of uric acid in the urine is small, and we find, further, that when it is treated with hypobromite, as much as 35 per cent. of the nitrogen in it is not evolved; with hippuric acid, nearly $82\frac{1}{2}$ per cent. of it is suppressed, and with creatinine, 25 per cent.

It is, then, obvious that the nitrogen which comes from other sources than the urea is very small, and may in all ordinary cases be neglected.

After trying solutions of different strengths, we find it most advantageous to use a solution of hypobromite prepared by dissolving 100 grams of common solid caustic soda in 250 c.c. of water, and adding 25 c.c. of bromine. This mixture gives a rapid and complete decomposition of the urea.

The form of the apparatus is shown in the accompanying sketch. A tube, A, about 9 inches long, is narrowed 2 inches from the closed end, and a bulb, B, holding about 12 c.c. blown on it. The upper part

of the tube contains about 25 c.c. This is fitted, by means of an india-rubber cork, into a small elliptic tin trough, C D, about 3 inches long, standing upon three legs. In using the apparatus, a 5 c.c. pipette is filled with the urine, and the liquid is allowed to flow into the bulb of this tube. Water is added, thus washing down the urine which adheres to the sides of the tube, and filling the bulb up to the top of the constriction. A glass rod, with a piece of india-rubber tubing about half an inch long drawn over the end of it, is then introduced, so that the india-rubber plugs up the constriction. The hypobromite solution is then poured into the upper part of tube until it is full, and the trough is afterwards half-filled with ordinary water.

A graduated tube, F, is filled with water, the thumb placed on the open end, and the tube is inverted in the trough. The glass rod is then pulled out, and the graduated tube slipped over the mouth of the bulb-tube.

The reaction commences immediately, and a torrent of gas rises

into the measuring tube. To prevent any of the gas being forced out by the reaction, the upper part of the bulb-tube is slightly narrowed, so that the gas is directed to the centre of the tube. With the strength of hypobromite solution, which we suggest, the reaction is complete in the cold in about ten or fifteen minutes; but in order to expedite it, the bulb is slightly warmed. This causes the mixing to take place more rapidly, and the reaction is then complete in five minutes. The reaction will be rapid and complete only when there is considerable excess of the hypobromite present. After the reaction the liquid should still have the characteristic colour of the hypobromite solution.

The amount of constriction in the tube is by no means a matter of indifference, as the rapidity with which the reaction takes place depends upon it. If the liquids mix too quickly, the evolution of the gas is so rapid that loss may occur. On the other hand, if the tube is too much constricted, the reaction takes place too slowly.

The simplest means of supporting the measuring-tube is to have the bulb-tube corked into a well, G, which projects from the bottom of the trough about 1 inch downwards. The graduated-tube stands over the bulb-tube, and rests upon the cork in the bottom of the well. It is convenient to have, at the other end of the trough, another well, H, which will form a support for the measuring-tube when not in use.

To avoid all calculation, we have the measuring-tube graduated so that the amount of gas read off expresses at once what may be called the percentage amount of urea in the urine experimented upon, *i.e.*, the number of grâms in 100 c.c., 5 c.c. being the quantity of urine taken in each case. The gas collected is nitrogen saturated with aqueous vapour, and the bulk will obviously be more or less affected by temperature and pressure. Alterations of the barometer produce so small an alteration in the volume of the gas, that it may be generally neglected; *e.g.*, if we have 30 c.c. of nitrogen, the quantity we prefer dealing with, an alteration of 1 inch in the height of barometer would produce an error in the amount of urea of about 0.003; but for more exact experiments, the correction for pressure should be introduced.

In the wards of hospitals, and in rooms where the experiments are most likely to be made, the temperature will not vary much from 65° F., and a fortunate compensation of errors occurs with this form of apparatus under these circumstances. The tension of the aqueous vapour, together with the expansion of the gas at this temperature, almost exactly counterbalances the loss of nitrogen in the reaction.

5 c.c. of a 2 per cent. standard solution of urea gave without correction :—

37.5	c.c.
37.0	"
37.0	"
37.2	"
36.9	"
37.5	"
37.0	"
36.9	"
37.0	"
37.2	"
36.9	"
37.1	"
37.1	"
37.0	"
<hr/>	
37.1	= the mean.

If the urea had given off the whole of its nitrogen, we ought to have obtained 37.3 c.c. Even under these circumstances the difference between these two numbers represents only 0.0007 grm. of urea. And even this error may be obviated by taking 37.1 as the basis for the graduation of the measuring tube instead of 37.3.

These 37.1 c.c. of moist nitrogen at a temperature of 65° F. correspond with 34.05 c.c. of nitrogen dry, at 0° C. and 760 mm. pressure. The following experiments were made with the gas apparatus, and the volume of gas in each case was corrected in the ordinary way for temperature, pressure, and moisture.

The first experiment gave	33.77 c.c.
The second	33.80 "
The mean being 33.75.	

Experiments with our apparatus, when corrected, gave—

	34.14
	34.2
	35.0
	34.56
	34.04
5	<hr/> 171.94
	34.39 = the mean.

Thus if the experiments be made under the conditions we have described, and no correction be introduced, there is only an error of 0.34 c.c., which corresponds with about 0.001 of urea. So that we are justified in assuming that this compensation takes place, and that 37.1 c.c. represents 0.1 gram of urea.

We also tested the method by taking a urine in which we had deter-

mined the amount of urea and then adding known weights of pure urea to it.

The urine gave—

1st experiment		35.0 c.c. nitrogen.
2nd	„	 34.8 „

To this a known quantity of a standard solution of urea was added, and this gave the following results:—

1st experiment		24.5 c.c.
2nd	„	 24.0 „
3rd	„	 24.3 „
Mean		 24.27 „
Calculated		 24.10 „

We find from experience that 5 c.c. of urine is the most advantageous quantity to employ, as it usually evolves a convenient bulk of gas to experiment with, *i.e.*, about 30 c.c. Now we have shown that 5 c.c. of a standard solution containing 2 per cent. of urea evolves this 37.1 c.c. of nitrogen. We have consequently taken this as the basis of the graduation of our measuring-tube. This bulk of gas is read off at once as 2 per cent. of urea, and in the same way the other gradations on the tube represent percentage amounts of urea.*

As unfortunately, in most medical works, it is the grain and ounce measures that are used, some tubes have been graduated so that on one side is the percentage composition and on the other grains per oz.

If the urine experimented with is very rich in urea, so that the 5 c.c. evolve a much larger volume of gas than 30 c.c., then it is best at once to dilute the urine with its own bulk of water, take 5 c.c. of this diluted urine, and multiply the volume of gas obtained by two.

If the urine contains much albumin; this interferes with the process so far that it takes a long time for the bubbles of gas to subside, before the volume of gas obtained can be accurately read off. It is therefore better in such cases to remove as much as possible of the albumin by heating the urine with two or three drops of acetic acid, filtering, and then using the filtrate in the usual manner. The presence of sugar in the urine does not affect the reaction.

In conclusion, we may state that the practical working of this apparatus fully confirms our expectation, that it is really an instrument sufficiently simple, easy to use, accurate, and inexpensive, to come into very general use, and already some interesting and important results have been obtained with it.

* The apparatus is made by E. Cetti, Brooke Street, Holborn, E.C., price 8s. 6d.