3848

Measurement of Hydrogen Ion Concentration by Means of the Glass Electrode.

M. L. ANSON AND A. E. MIRSKY. (Introduced by Alfred E. Cohn.)

From the Department of Animal Pathology of the Rockefeller Institute and from the Hospital of the Rockefeller Institute.

Acidity plays such an important rôle in modern biology that the methods of measuring it are of considerable interest. A method has recently been introduced that is admirably adapted to many needs of experimental biology. The glass electrode is as accurate as the hydrogen electrode, as rapid as the quinhydrone electrode, and (once the apparatus has been set up) as easy to use as colorimetric methods. It can, moreover, be used under conditions when no other method is applicable—for example, for the direct measurement of the pH of whole blood.

The glass electrode was gradually developed over a period of fifty years by a number of investigators (including Lord Kelvin,[1] Cremer[2] and Haber[3]); its recent application to the exact measurement of hydrogen ion concentration is due to Kerridge.[4] We have used it for this purpose, but to obtain satisfactory results we find it necessary to take a precaution that is hardly mentioned in previous papers on the glass electrode. At the same time, we have introduced several modifications that simplify and shorten the manipulations.

One form of electrode consists of a glass tube, one end of which is blown to a very thin bulb, a depression in which forms the membrane. If on the 2 sides of the membrane are placed 2 solutions of different pH, a potential difference is set up, and under certain conditions, this potential is determined by the difference in pH of the 2 solutions. Consequently, if the pH of one solution and the membrane potential are known, the pH of the other solution can be calculated. For the measurement of potential the current is led off from each solution by means of a KCl bridge to a calomel half cell. The difficulty we have encountered is concerned with the KCl, for if it contaminates the solutions, variable and irreproducible potentials are obtained. Contamination does not occur by diffusion, but simply because a saturated KCl solution is relatively heavy and tends to flow down. An obvious way, therefore, of avoiding the difficulty is to introduce the KCl from below, and this we have done. It is often convenient, however, to dip the bridge in from above. To avoid contamination, we attach to each bridge a tip with a very

fine opening and containing KCl in agar. An even simpler way of "avoiding" KCl contamination in the solution of *known* pH is to prepare it saturated with KCl, in which case this bridge can be left in permanently. A further step is to seal the glass electrode to the calomel half cell and thus dispense with this KCl bridge. By this manoeuvre the half cell and the electrode form one piece.

After a little practice it is easy to blow the electrode oneself. In the construction of a stand, the arms which support the electrode and calomel cells are made of amber for insulation, but we find quartz more convenient. The only instruments one need purchase are a potentiometer of the usual type and an electrometer. We have used the Lindemann electrometer supplied by the Cambridge Instrument Company. The rest of the apparatus is easily made.

[1] Thomson, W., *Proc. Roy. Soc. London*, 1874-75, xxiii, 463.

[2] Cremer, M., *Z. Biol.*, 1906, xlvii, 562.

[3] Haber, F., und Klemensiewicz, H., *Z. physik. Chem.*, 1906, lxvii, 385.

[4] Kerridge, P. M. T., *The Biochem. J.*, 1925, xix, 611, and *J. Scientific Instruments*, 1926, iii, 404.

3849

Changes in Lactic Acid and Glucose in the Blood on Passage Through Organs.

H. E. HIMWICH, Y. D. KOSKOFF AND L. H. NAHUM.

From the Department of Physiology, Yale University.

The following research was undertaken to determine the factors regulating the concentration of lactic acid in the blood of mammals. Observations were made on 32 dogs most of which were decerebrate. The amount of lactic acid in the arterial blood was compared with that of the blood draining the liver, spleen, portal system, kidney, testicle, lower extremities, brain, thyroid, lungs and heart. Lactic acid was estimated by the method of Shaffer, Cotonio and Friedemann. Sugar was determined by the Shaffer-Hartmann method. A difference of 5 mg. % or more between the lactic acid content in the arterial and venous samples was considered significant. Typical results are found in Table I, where the muscle poured lactic acid in the blood stream and the liver removed it. Thus, in 27 of 51 observations the muscles added to the lactic acid content of the blood passing through them. In 19 cases the difference between arterial and venous blood was not considered signifi-