

now so large that our sense of proportion demands that attention should no longer be directed almost exclusively to the study of carbon compounds.

There is one other problem to which I would direct attention—the study of liquid diffusion. No interpretation of the remarkable results obtained by Graham has yet been given, and they appear in many cases to be quite at variance with the results of chemical inquiries. But there is a striking parallelism to be observed between Graham's results and those obtained on determining the electrical conductivity of solutions. Applying the view which I hold regarding the electrolysis of composite electrolytes to liquid diffusion, it appears to me not improbable that diffusion may be to a large extent the outcome not so much of the proper motion of the molecules of the dissolved substance as of a propulsive action exercised by the molecules of the solvent. The molecules in a mass of water we know may be assumed to be moving in every direction, and this being the case they would tend to carry other molecules along with them: the extent to which this action would take place would, however, largely depend on the attraction which exists between the molecules of water and those of the dissolved substance. From this point of view it appears of considerable importance to extend the study of liquid diffusion to dilute solutions. It may be added that this hypothesis would probably account for the behaviour of colloids, as these are known to be chemically neutral substances; in fact, they are compounds almost destitute of residual affinity.

#### UNIVERSITY AND EDUCATIONAL INTELLIGENCE

KING'S COLLEGE, LONDON.—Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on Electro-Magnetism, Magneto-Electricity, the Testing of Motors and Dynamos, Electric Lighting, and Transmission of Power, during the present Term.

A course of practical work in Electrical Testing and Measurement with especial reference to Electrical Engineering will also be carried on under his direction in the Wheatstone Laboratory.

The lectures will be given once a week—on Mondays, at 2 p.m.,—and the Wheatstone Laboratory is open daily from 1 to 4, except on Saturdays.

#### SOCIETIES AND ACADEMIES

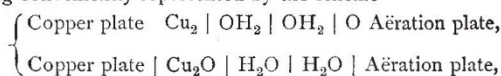
##### LONDON

Royal Society, March 31.—“Note on the Development of Voltaic Electricity by Atmospheric Oxidation.” By C. R. Alder Wright, D.Sc., F.R.S., Lecturer on Chemistry and Physics, and C. Thompson, F.C.S., Demonstrator of Chemistry, in St. Mary's Hospital Medical School.

Whilst investigating processes for the manufacture of cuprammonium hydroxide (now used commercially on a considerable scale) we noticed that if the air supply be greatly in deficiency relatively to the bulk of the copper, under certain conditions the solution is but little coloured, containing copper dissolved principally as cuprous, and not as cupric, oxide. This might, perhaps, be anticipated *a priori*, inasmuch as it is well known that blue cupric solution in ammonia, when digested with metallic copper in the absence of air, takes up a second equivalent of copper, becoming colourless cuprous solution; but further experiments seem to indicate that the production of cuprous oxide under the oxidising influence of a limited supply of air is the primary action, and not merely a secondary result.

When a sheet of copper is kept out of direct contact with air by being immersed in ammonia solution, oxidation of the metal is gradually effected by virtue of the dissolving of oxygen from the air at the surface of the fluid, and diffusion of the oxygen solution to the vicinity of the copper. This action is an extremely slow one if the copper be covered by some depth of fluid, and if the setting up of convection currents through heating or evaporation be prevented by keeping the vessel perfectly at rest and at an equable temperature, and well closed to prevent escape of ammonia; but if these precautions be neglected it goes on much more rapidly, and the liquid comparatively soon becomes blue; it can, however, be also materially accelerated by arranging horizontally on the surface of the fluid a plate of platinum or other electrically conducting material not chemically acted upon by the fluid, and connecting this by means of a wire, &c., with the copper plate. The upper conductor, or *aération*

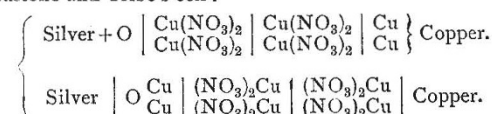
plate as it may be conveniently termed, being simultaneously in contact with the atmosphere and fluid, attracts to its surface a film or aura of condensed gases, the oxygen of which becomes gradually transferred to the copper, a voltaic current circulating through the fluid and connecting wire. Cuprous, and not cupric, oxide thus results, dissolved in the ammonia solution in contact with the copper plate, the mechanism of the reaction being conveniently represented by the scheme—



water being represented as the electrolyte for simplicity's sake. The air film on the aération plate being constantly renewed by absorption from the atmosphere, the process goes on continuously as long as the two plates are connected together by the wire. This wire may be lengthened at will so as to make the current which passes through it whilst the action goes on relatively stronger or weaker according to the amount of resistance introduced into the circuit; and by including a galvanometer or silver voltameter in the circuit the ordinary phenomena due to the passage of currents are readily recognisable.

The maximum E.M.F. thus capable of development varies considerably with the strength of the ammoniacal solution, being the less the weaker the fluid; addition of common salt or of sal ammoniac to the liquid notably increases the E.M.F. and diminishes the internal resistance of the cell. Spongy platinum in a thin layer as the aération plate gives higher values than thin platinum foil; the highest numbers thus obtained, using pretty concentrated ammoniacal brine, fell but little short of 0.8 volt; or somewhat less than the E.M.F. corresponding with the heat of formation of cuprous oxide,<sup>1</sup> since, according to Julius Thomsen,  $\text{Cu}_2\text{O} = 40,810 = \text{about } 0.88 \text{ volt}$ .

It is obvious that this copper atmospheric oxidation cell has a close connexion with the “air-battery” described in 1873 by Gladstone and Tribe (Roy. Soc. Proc., vol. xxi. p. 247) in which what is virtually an “aération plate,” consisting of a tray full of crystals of silver is used, opposed to a copper plate immersed in a solution of copper nitrate. Cuprous oxide is formed in both cases, in virtue of the indirect combination brought about between the oxygen of the air and the copper: but there is this great difference between the two (apart from the cuprous oxide being deposited as such in Gladstone and Tribe's arrangement, and being kept in solution in ours), that in the one the cuprous oxide is formed *at the surface of the copper plate* itself, and in the other *at the surface of the aération plate*. This essential difference is embodied in the above depicted scheme as compared with the following one which represents the action in Gladstone and Tribe's cell:—



One result of this difference is that the surface of the aération plate in the ammonia cell is kept constantly the same, whereas in the nitrate cell it is continually changing its character through deposition of solid cuprous oxide on the silver: in consequence of this deposition, whilst the E.M.F. of the ammonia cell, *ceteris paribus*, is constant, that of the nitrate cell is continually varying. Gladstone and Tribe, moreover, only obtained an E.M.F. of  $\frac{8}{10}$  to  $\frac{11}{10}$  of a Daniell, or about 0.104 to 0.143 volt, even under the most favourable conditions, viz. when the cell was connected with an electrometer; whilst four or five times this amount is indicated by the cells examined by us.

Following up the ideas suggested by the above observations, we are making a number of experiments with a variety of analogous combinations, in which atmospheric oxidation constitutes the essential chemical action taking place; by varying the nature of the aération plates, the metals dissolved, and the liquids employed (as also by substituting other gases, e.g. chlorine, for air), a large number of combinations are obviously obtainable. Some of those which we have so far examined present points of considerable interest, the oxidising action exerted under favourable conditions being strongly marked: so much so that certain metals, e.g. mercury and silver, not ordin-

<sup>1</sup> The actual chemical change going on in the cell is the synthesis of cuproso-ammonium hydroxide, so that the (unknown) heat of solution of cuprous oxide in ammonia should be added to this to obtain the total heat development.