

December 15, 1887.

Professor G. G. STOKES, D.C.L., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The President read a letter from H.M. Secretary of State for Home Affairs, announcing that Her Majesty had "been graciously pleased to command that the Royal Society be allowed to enjoy the privilege, on all fit and proper occasions, of presenting their addresses to the Sovereign on the Throne."

The President was requested to convey to the Home Secretary the thanks of the Society for his communication, and to express their satisfaction that Her Majesty had been graciously pleased to honour the Society with this mark of the Royal recognition.

The following Papers were read:—

- I. "Note on the Development of Feeble Currents by purely Physical Action, and on the Oxidation under Voltaic Influences of Metals not ordinarily regarded as spontaneously oxidisable." By C. R. ALDER WRIGHT, D.Sc., F.R.S., Lecturer on Chemistry and Physics, and C. THOMPSON, F.C.S., F.I.C., Demonstrator of Chemistry, in St. Mary's Hospital Medical School. Received November 24, 1887.

In the course of a series of further experiments on cells set up with "aeration plates" (plates simultaneously in contact with the air and the electrolytic fluid used in the cells—'Roy. Soc. Proc.,' vol. 42, p. 212), we have made a large number of determinations of the E.M.Fs. developed with incorrodible aeration plates of various kinds (*e.g.*, platinum foil, spongy platinum, thin sheet gold, &c.) when opposed to the same oxidisable metal, such as copper or zinc, in contact with the same electrolytic fluid, *e.g.*, dilute sulphuric acid or caustic soda solution. The details of these observations, when completed, will form the subject of a future paper; whilst making them we have noticed that if two or more different kinds of aeration plates be set up on the surface of the fluid contained in a shallow basin in which the oxidisable metal is immersed, and sufficient time be allowed to elapse to enable the films of air attracted to the aeration plates to attain a

condition of equilibrium, different constant values are usually obtained for the E.M.Fs. generated by opposing to the oxidisable metal first one and then the other of any given pair of aeration plates, the currents generated being rendered throughout of too small density for "running down" to take place during the observations by interposing a large resistance in the circuit. If when this state of constancy has been attained the two aeration plates be opposed to each other with a considerable resistance in circuit, a current passes from the one giving the higher value when opposed to the oxidisable plate through the external circuit to the other. This current at first is of such magnitude as to correspond exactly with the E.M.F. due to the difference between the E.M.Fs. exhibited when the two plates respectively are opposed to the oxidisable metal, but after some time it gradually diminishes; even after several days, or even weeks, however, it is usually still measurable. If a miniature silver voltameter be included in the circuit, in many cases an appreciable amount of crystalline silver is found to be slowly deposited on the negative electrode of the voltameter, which may conveniently be a thin gold wire immersed to a depth of a few millimetres in silver nitrate solution, a silver plate or wire forming the positive electrode. Thus, for example, in various experiments the following figures were obtained, the aeration plates being arranged on the surface of dilute sulphuric acid:—

Nature of aeration plates.	Time in days.	Silver deposited in voltameter in milligrams.	Average current in microampères during the period.
1. Spongy platinum and smooth platinum foil	14	10·5	7·7
2. Ditto ditto	18	1·5	0·8
3. Spongy platinum and smooth gold plate	24	6·5	2·8
4. Spongy gold and smooth gold plate	14	1·0	0·7
5. Spongy gold and platinum foil	24	1·25	0·5

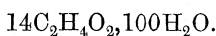
Analogous results were obtained in various other cases with different electrolytic fluids, *e.g.*, spongy silver and smooth silver sheet with caustic soda solution. In every case the action was greatest at first and gradually diminished, but never became absolutely *nil*. The larger the surface of the aeration plates, as might be expected, the greater was the average current; thus in experiment No. 1 above, plates exposing about 20 sq.c. surface (one side, superficial measure-

ment not reckoning inequalities of sponge) were used, and in No. 2 plates only about one-fifth that size.

It is obvious that during the passage of a current the dilute sulphuric acid between the two plates must be electrolysed, so that hydrogen would tend to be liberated on the surface of the plate acquiring the higher potential, and oxygen on that of the other; the hydrogen whilst nascent would necessarily be more or less completely oxidised to water by the oxygen of the film of condensed air, so that on the whole the net chemical action in the cell itself would be either *nil* (if all hydrogen were so re-oxidised) or one *absorbing* heat (if some of the hydrogen escaped oxidation). The oxygen slowly evolved would escape as such, being dissolved by the surrounding fluid. The effect of this should accordingly be that the efficiency of the air film on the first plate would be more or less depreciated, and that on the second exalted; in point of fact, if the two aeration plates in such an arrangement, which has been generating a current for some time, be (by means of an appropriate switch) disconnected from one another and successively opposed to a given oxidisable plate, the one does give a considerably lower and the other usually an appreciably higher value than the constant ones previously obtained (before the two aeration plates were directly opposed to one another) on opposing each severally to the oxidisable metal; whilst on allowing the cell to stand for some time generating no current, the lower value gradually rises and the raised one falls until sensibly the old constant values are again obtained.

We noticed, moreover, that when aeration plates of platinum-foil or sponge are used opposed to *silver* plates in conjunction with a fluid capable of dissolving silver oxide (such as dilute sulphuric or acetic acid or ammonia solution) distinctly larger amounts of current are usually developed than when opposed to carbon or gold plates, and that simultaneously silver passes into solution, the silver plate acquiring the lower potential, diminishing in weight, and, in short, behaving precisely as though it were an oxidisable metal, such as zinc or copper. Obviously this is due to the circumstance that with silver the oxygen liberated attacks the metal of the plate acquiring the lower potential; but the remarkable part of the action is that this attack is only partial, so that the amount of silver dissolved is invariably *less than that equivalent to the current passing, i.e., less than that deposited* in a silver voltameter included in the circuit. Thus the following numbers were obtained in a series of experiments, in each of which four similar cells containing platinum sponge aeration plates arranged in series were used in order to shorten the time of observation. The electrolytic fluids used in the various cases were respectively:—

A. Acetic acid solution, approximately of strength



B. Ditto also containing sodium acetate, approximately of strength
 $10\text{C}_2\text{H}_4\text{O}_2, 10\text{NaC}_2\text{H}_3\text{O}_2, 100\text{H}_2\text{O}.$

C. Ammonia solution originally of strength $10\text{NH}_3, 100\text{H}_2\text{O}$, but considerably weakened during the experiment by evaporation.

D. Ammonia solution also containing ammonium sulphate; originally $10\text{NH}_3, 2\cdot5(\text{NH}_4)_2\text{SO}_4, 100\text{H}_2\text{O}.$

E. Ammonia solution also containing sal-ammoniac; originally of strength $10\text{NH}_3, 5\text{NH}_4\text{Cl}, 100\text{H}_2\text{O}.$

F. Dilute sulphuric acid, $4\text{H}_2\text{SO}_4, 100\text{H}_2\text{O}.$

Time in hours.	Silver dissolved		Silver deposited in voltameter.	Per cell per 24 hours.		Difference.
	In 4 cells jointly.	Per cell.		Silver deposited.	Silver dissolved.	
A. 180	0·003	0·00075	0·0025	0·00033	0·00010	0·00023
B. 130	0·0045	0·001125	0·0020	0·00037	0·00021	0·00016
C. 68	0·015	0·00375	0·0060	0·0021	0·0014	0·0007
D. 136	0·1095	0·027375	0·037	0·0065	0·0048	0·0017
E. 44	0·086	0·0215	0·027	0·0147	0·0117	0·0030
F. 96	0·348	0·087	0·097	0·0242	0·0217	0·0025

The difference between the silver dissolved and that deposited by the current is thus relatively much larger with the weakest currents, representing 43—69 per cent. of the latter in cases A and B; 26—33 per cent. in cases C and D; and 10—20 per cent. in cases E and F.

It is obvious that if silver will dissolve in acids, &c., under the comparatively feeble oxidising influence of an aeration plate, much more rapid solution might be anticipated by substituting for such a plate platinum immersed in a powerfully oxidising fluid such as strong nitric acid, or sulphuric acid solution of chromic anhydride. In point of fact, we have found that on setting up such cells where the silver was immersed in dilute sulphuric acid (*i.e.*, Grove's cell with silver instead of zinc, and so on), electromotors of notable power are produced, at any rate until the silver plate becomes coated with sparingly soluble sulphate. Even in these cases, however, perfect correspondence between the amount of silver dissolved and that deposited in a voltameter included in the circuit does not subsist, the latter being always measurably the greater. Thus in several experiments with such cells, when the current was so regulated by interpos-

ing suitable resistances that the silver deposition in the voltameter was brought down to 0·1 to 0·2 gram of silver per 24 hours, the silver deposited always exceeded that dissolved by 0·001 to 0·003 gram. Similarly two duplicate cells set up with silver plates immersed in ammonia solution containing sal-ammoniac of strength about



and opposed to platinum immersed in sulphuric acid solution containing chromic anhydride, gave the following figures, much more resistance being in circuit in the second experiment than in the first.

Time.	Silver deposited in voltameter.	Silver dissolved from plate.	Difference.
18 hours	0·514 gram	0·510	0·004
46 "	0·107 "	0·106	0·001

A similar cell containing ammonia solution without sal-ammoniac, and consequently having a very large internal resistance, caused only 0·013 gram of silver to be dissolved in eighteen hours, whilst 0·015 gram was deposited; in this case a visible film of silver peroxide was formed on the silver plate (a wire of pure metal).

Just as silver is capable of being dissolved in an appropriate fluid when opposed to an aeration plate, so may several other metals not ordinarily prone to atmospheric oxidation; thus mercury with dilute sulphuric acid as fluid, and an aeration plate of platinum sponge, generates a measurable continuous current, forming *mercurous sulphate* in so doing, so that after some time the liquid becomes turbid through separation of that sparingly soluble salt, and the filtered fluid precipitates calomel on addition of dilute hydrochloric acid. Acetic acid acts similarly, but far less energetically. Potassium cyanide solution, on the other hand, causes a much more rapid solution of mercury, forming *mercuric potassiocyanide*; it is noticeable that in this case only 100 parts of mercury go into solution for 108 of silver deposited in the voltameter, whereas when sulphuric acid is used 200 parts of mercury become sulphate per 108 of silver deposited.

If gold be substituted for mercury in this latter arrangement, rapid solution takes place with formation of *aurocyanide of potassium*, 196 parts of gold being dissolved per 108 of silver thrown down in the voltameter; the rate of action here, as in other analogous cases, can be notably increased by placing the gold plate and potassium cyanide solution in one basin and the aeration plate (platinum sponge) in another with sulphuric acid, uniting the two fluids by a wide siphon,

so as to superadd to the other E.M.Fs. in operation that due to the mutual neutralisation of the acid and alkali.

Palladium behaves precisely as gold, 52 parts of metal being dissolved per 108 of silver deposited; local action sometimes causes in each case *excess* of amount dissolved relatively to the current passing, the opposite result to that observed with the silver cells above described.

Of course, if more powerful oxidising agents are used than simple aeration plates (such as platinum in sulphuric-chromic solution), the action goes on in all such cases still more rapidly; thus, for example, we did not succeed in dissolving gold in dilute hydrochloric alone by the use of an aeration plate simply; but on replacing this by a platinum plate immersed in sulphuric-chromic liquor connected by a siphon with the dilute hydrochloric acid in which the gold was immersed, chlorination of the gold was readily effected with the formation in the first instance of *aurous chloride*, which rapidly broke up into particles of spongy gold and auric chloride in solution.

II. "The Early Development of the Pericardium, Diaphragm, and Great Veins." By C. B. LOCKWOOD, F.R.C.S., Hunterian Professor of Anatomy in the Royal College of Surgeons of England. Communicated by G. M. HUMPHRY, F.R.S. Received November 26, 1887.

(Abstract.)

The history of the development of the pericardium, diaphragm, and great veins is traced by means of rabbit's embryos ranging from the eighth to the seventeenth day of intrauterine life.

The splanchnic origin of the two halves of the heart is briefly illustrated, and each separate half is shown to project into the foremost end of the cœlom. The approximation of the halves of the heart, and of the cœlom in which they are contained, and the formation of the mesocardium posterius and antierius, is next narrated. The course of the omphalomesenteric veins to the heart along the splanchnic wall of the cœlom is then traced, and those vessels are shown to divide the cœlom into two parts, a "cardiac" and a "pleuro-peritoneal." At the beginning of the ninth day the cœlom consists of two halves which are some distance apart towards the tail end, but converge towards the head to open behind the omphalomesenteric veins, into the cardiac portions of the cœlom. To adopt a rough comparison, the cœlom is, at the beginning of the ninth day, not unlike a pair of trousers; the cardiac portion would correspond to that part of the trousers which receives the pelvis, whilst the hinder parts of the cœlom would correspond to the places for the legs. To