liquid were produced without electrolysis, and electrolysis would reasonably account for several of the phenomena, it was concluded that electrolysis was not merely a concomitant circumstance, but also acted as a cause. The converse phenomena of the subject of this paper have been made the subject of a separate research, entitled "The Production of Electric Currents by Diffusion and Osmose of Liquids." No effect of magnetism upon the lines or movements of the liquids was sought for.

Chemical action was found to be only a coincident and not a fundamental part of the phenomena; it constantly took place by electrolysis and by contact of liberated ions, and occasionally by contact of the original liquids. The lines and strata of liquid at the meniscuses were produced with almost every possible chemical combination of electrolytes; and references are given to experiments which prove this; they were also the more difficult to produce the less the differences of chemical composition of the two liquids.

VIII. "Experiments on Electric Osmose." By G. Gore, LL.D., F.R.S. Received December 7, 1880.

The following experiments were made for the purpose of elucidating a question in a research on "The Influence of Voltaic Currents on the Diffusion of Liquids" (*ante*, p. 250), and are published separately, in order to facilitate reference to them by other investigators.

As, also, the discovery of an exceptional instance is often of considerable importance, an additional number and variety of solutions were purposely examined with that further object until such a one was found. I anticipated that the proportion of exceptional instances would be "about one or two per cent."

The experiments were similar to that made by Porrett ("Annals of Philosophy," vol. 8, p. 74). The vessel employed was about 7·0 centims. high and 3·0 centims. diameter, of thick glass, divided vertically into two equal parts, its edges being covered with vulcanised india-rubber, with a diaphragm of biscuit ware about 1·5 millim. thick placed between them; the whole being held together between two upright bars of wood by means of a clamp-screw, so that the diaphragm might be readily removed, and replaced by a clean one. The electrodes were of sheet platinum, about 18 millims. wide; and the electric current (except in the cases otherwise mentioned) was from 12 Grove's cells of one pint capacity, and in single series. The liquid was usually about 2 centims. high in the vessel, and at the same level on each side of the partition previous to passing the current in each experiment. The diaphragm was frequently changed.

The following table exhibits the compositions of the liquids tried,

and briefly the results. The electric current was in all cases sent from left to right.

No.	Substance.	Strength of Solution.	Direction of flow of liquid.
1	Yellow potassic chromate	Saturated solution	→
2	" " "	Very diluted solution	→
3	Distilled water..............	....	→
4	Potassic cyanide	1 gr. per oz................	→
5	" "	10 grs. "	→
6	Chromic acid (crystals)	1 gr. "	→
7	" " "	10 grs. "	→
8	Potassic nitrate	10 grs. "	→
9	Sodic nitrate...............	10 grs. "	→
10	Strontic nitrate	5 grs. "	→
11	Baric nitrate...............	5 grs. "	→
12	Ammonic nitrate............	10 grs. "	→
13	Potassic sulphate...........	10 grs. "	→
14	Ammonic sulphate	10 grs. "	→
15	Ammonic alum.............	10 grs. "	→
16	" "	5 grs. "	→
17	Potassic sulphate...........	Saturated solution	→
18	Oxalic acid	63 grms. per litre	→
19	Nitric acid	1 volume of acid, and 5 water	→
20	Acid sulphate of sodium	Saturated solution	→
21	Glacial phosphoric acid	400 grs. per oz...	→
22	Potassic carbonate	5 grs. "	→
23	Sodic carbonate	5 grs. "	→
24	Borax	5 grs. "	→
25	Microcosmic salt	5 grs. "	→
26	" "	10 grs. "	→
27	Sodic phosphate	10 grs. "	→
28	Ammonic phosphate	10 grs. "	→
29	Potassic sulphite	5 grs. "	→
30	Sodic sulphite	5 grs. "	→
31	" "	1 gr. "	→
32	Sodic hyposulphite	5 grs. "	→
33	Potassic chloride	2 ozs. salt in 12 ozs. water....	→
34	Potassic bromide...........	200 grs. per oz..............	→
35	Sodic formiate	5 grs. "	→
36	" "	10 grs. "	→
37	Potassic ferrocyanide	1½ oz. salt in 12 ozs. water....	→
38	Sodic selenate	2½ grs. per oz...............	→
39	Nitrate of lithium	Strong solution	→
40	Calcic nitrate	" "	→
41	Selenic acid	2 minims. per oz............	→
42	Formic acid	8 " "	→
43	Iodic acid..................	Moderately strong solution....	→
44	Perchloric acid.............	Strong solution..............	→
45	Chloric acid...............	" "	→
46	Hydrochloric acid	1 volume acid, 5 water	→
47	Potassic hydrate	½ oz. in 14 ozs. water	→
48	" "	5 grs. in 100 c.c. water	→
49	Sodic silicate...............	Rather weak solution	→
50	Potassic chlorate	" " "	→
51	Ammonic chloride	1 oz. in 8 ozs. water	→
52	Ammonic molybdate with aqueous ammonia	....	→

No.	Substance.	Strength of Solution.	Direction of flow of liquid
53	Sulphocyanide of ammonium..	Strong solution	→?*
54	Tungstate of potassium	Saturated solution	→
55	Phosphorous acid	Strong solution..............	→
56	Arseniate of sodium	....	→
57	Potassic fluoride (pure)	....	→
58	Liquor arsenicalis	British Pharmacopœia strength	→
59	Hypophosphorus acid	Saturated solution	→
60	Sulphocyanide of potassium ..	Strong solution	→?*
61	Ferridcyanide of potassium....	Moderately strong solution ...	→
62	Sodic hydrate...............	Strong aqueous solution	→
63	Potassic cyanide.............	Saturated solution...........	No perceptible flow.
64	Sodic carbonate.............	" "	→
65	Potassic carbonate	" "	→
†66	Sodic hydrate	200 grs. in 1 oz. absolute alcohol	→
†67	Hypophosphite of sodium	Strong alcoholic solution......	→
†68	Baric bromide	Nearly saturated alcoholic solution	←

In all the foregoing experiments (sixty-eight in number), in which an electric current passed from one portion of liquid through a clay diaphragm to another portion, osmose occurred, except in No. 63.

In these experiments, fifty-five substances, different in kind, were employed, including about twenty-seven neutral salts of the most varied composition, about ten alkaline ones, twelve acids, two alkalies, and one acid salt; twelve of the substances of different degrees of dilution were also examined.

As with solutions of potassic cyanide, yellow potassic chromate, acid chromate of potassium, or sodic carbonate (liquids which show an apparent opposite movement in the research referred to), the osmose was in the same direction as the electric current, and showed no sign of reversal of movement, I conclude that the apparent movement of the lower liquid in that research is probably of a different character from "electric osmose."

From these experiments, it also appears that the direction of electric osmose is in nearly all cases the same as that of the current; that rapid electric osmose is not confined to dilute solutions; and that in some cases too concentrated a solution prevented the effect (compare Nos. 17–20, 54, also 4, 5, and 63).

From the circumstance that the direction of osmose was the same in

* In consequence of the large quantity of orange-red solid matter liberated, the direction of the osmose could not be determined.

† In these three experiments a current from a single series of 25 Grove's cells was employed.

the most diverse solutions, viz., in acids, alkalies, neutral salts, aqueous and alcoholic liquids, concentrated and dilute solutions, &c., we might be apt to infer that the chemical composition of the electrolyte had no influence upon it; but as a single exceptional instance will overturn the widest generalisation, so the exceptional behaviour of a solution of bromide of barium in absolute alcohol invalidates the conclusion that the direction of flow of liquids in electric osmose, is independent of the chemical composition and molecular structure of the liquid. The danger of drawing conclusions from too limited a number of instances is well illustrated in this case, especially when we further remember that it is the exceptional instances which usually disclose the widest truths.

As the exceptions formed a very small proportion of the whole number of examples, it would appear that the direction of the flow depended very much more frequently upon the direction of the electric current than upon the internal architecture of the liquid.

In order to be able to compare the direction of motion of the mass of the liquids, produced by passing an electric current from a heavier to a lighter liquid lying upon it without a separating diaphragm, in the research already referred to, with that produced when the liquids were separated by a vertical diaphragm, additional experiments were made. The osmose cells employed in these experiments were about 4·7 centims. high, 2·5 centims. long, and about 2·0 centims. wide at right angles to the diaphragm; and the diaphragms were cemented in with sealing-wax.

Experiment 1.—Current from 26 Grove's cells in single series, passed from a saturated solution of sodic sulphate to a one-fourth saturated one of potassic chloride. Osmose occurred in the direction of the current.

Experiment 2.—Current passed from a mixture of 1 volume of sulphuric acid and 7 of water to one composed of 5 volumes of a saturated solution of oxalic acid, and 3 of water. Osmose produced in the usual direction.

Experiment 3.—Current passed from a strong solution of potassic chloride to a mixture of 1 volume of a saturated one of ammonic sulphate and 3 volumes of water. Rapid osmose took place in the ordinary direction.

Experiment 4.—Current from 5 Grove's cells in single series, passed from a solution composed of 1 volume of a concentrated solution of sodic hydrate and 3 volumes of water, to a saturated one of sodic carbonate. Osmose occurred in the usual direction.

Experiment 5.—The same current, passed from a strong solution of ammonic nitrate to one of 1 volume of a saturated solution of sodic carbonate and 3 volumes of water. Feeble osmose in the ordinary direction took place.

From the results of these experiments, and of those referred to, it appears that the presence of the diaphragm considerably affects the directions of the movements.

By means of numerous experiments subsequently made, it was also found that electric osmose usually proceeds more rapidly from a weak to a strong solution of a given substance than in the reverse direction.

The Society adjourned over the Christmas Recess to Thursday, January 6th, 1881.

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