Effect of Radium on Electrolytic Conductivity.

By Ryland Ratliff.

The material used was one-tenth of a gram of "Curie" radium chloride of 10,000 strength placed at the disposal of the writer through the kindness of Dr. Foley and the other Indiana University authorities.

A number of the usual experiments were first performed to test the quality of the material. These included photographing the fluorescent action of the radium upon small diamonds and Wilhemite. In these and kindred experiments good results were obtained.

Two attempts were made to obtain a photograph of the spectrum by means of the Rowland concave and Brashear mounting. In the first exposure of 90 hours the radium chloride was placed directly in front of the slit which was made unusually wide (probably too wide). A second exposure of 162 hours was made by placing the radium slightly to one side of the slit and the fluorescing Wilhemite directly in front of it. In this trial the slit was made narrower but was considerably wider than in ordinary spectrum work. Neither exposure yielded any effect other than a slight fogging of the plate. The remainder of the work was devoted to the problem, as above stated, of determining the effect upon electrolytic conductivity.

The apparatus employed is represented diagrammatically in Fig. 1.

Glass tubes I and II filled with the electrolytic solution are introduced into the two arms of the Wheatstone bridge BD and CD. The copper disks d_1 and d_2 are placed as nearly as possible the same distance apart as d_3 and d_4. Then when resistances R and R_1 are made the same the bridge will of course be balanced approximately. R and R_1 were usually made of from 800 to 1,200 ohms each. With the bridge balanced the radium is placed as near as practicable to I or II and the direction and amount of deflection in each case is noted.

Theoretically the back E. M. F. should be the same in each tube, but it was found to be impossible to get it so in practice for any considerable time. Hence the greatest difficulty in the way of definite positive conclusive results is due to the drift of the needle. A Rowland D'Arsonval galvanometer with a sensitiveness of one megohm was employed in the major part of the work.

The tubes were first filled with an almost saturated solution of Cu So_4. On working for two days with this electrolyte trying many different adjustments it was found that the back or electrolytic E. M. F. was so variable that no reliable results could be secured. The only thing determined positively was that lengthening the distance between the disks in I caused a deflection E, and lengthening that in II produced a deflection W.

On filling the tubes with pure distilled water the results were somewhat more definite. With the disks 1½ cm. apart the following data

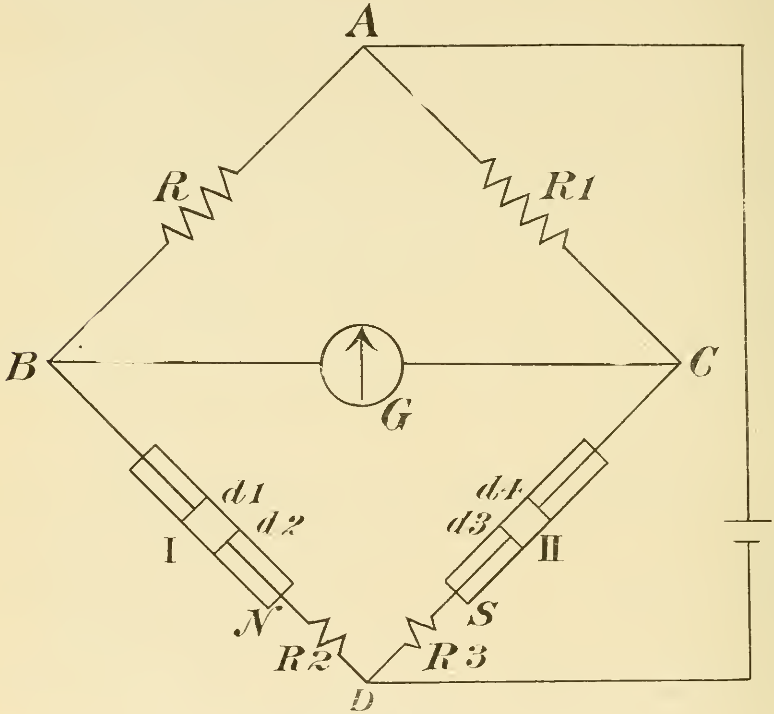

Figure 1.

Dimensions of essential parts of apparatus of Figure 1.

(1) Glass tubes, I and II.

Length of each, 10 cm.

Internal diameter of each, 17 mm.

(2) Copper discs, d1, d2, d3, and d4.

Diameter of each, 16 mm.

Thickness of each, 1 mm.

were obtained: (1) On closing circuit, deflection (W) was first 38, then settled at 22, on standing at 22 several seconds, radium placed nearest II gave deflection (E) to 34½. On removal deflection was W.

Since an E deflection indicates a decrease in the resistance of II the first results secured seemed fairly definite. To make sure the movements were not due to the E. M. F. of the electrolyte, weights were placed on the keys by which the battery and galvanometer circuits were both kept closed for a considerable time until the needle had ceased to drift. Four additional readings were taken, the five sets of readings being as follows: in all the lists of readings deflections indicating a decrease of resistance by the presence of the radium are marked +, those indicating an increase are marked —:

TABLE I.

Reading.	Reading on addition of radium.	Deflection.	Reading on removal of radium.	Deflection.
(1) 22	34.5	+12.5	W	+
(2) 23	42	+19	41.7	+3
(3) 41.4	41.7	+ .3	41 65	+ .05
(4) 41.65	41.65	0	41.65	0
(5) 41.2	41.7	+ .5	41.7	0

Two drops of $H_2S\ O_4$ were added to the water with which the tubes were now filled. This of course greatly increased the conductivity. It also made it much more difficult to balance the bridge. In securing the data given in table II the radium was placed alternately upon the two tubes, N and S.

TABLE II.

Reading at beginning.	Radium on N	Result.	Radium on S.	Result.
33.5	33.5	0	33.85	+ .35
	34.1	— .25	34 5	+ .4
	34.4	+ .1	34.5	+ .1

The results only of the readings will be given in the succeeding lists. The tubes were now enclosed in pasteboard boxes to prevent effects due to light and heat. Each box had a hole just large enough for the insertion of the radium.

TABLE III.

Radium added.	Radium removed.
+ .7	0
+ .10	+ .15
+ .10	+ .13
— .13	+2.
— .05	+ .05
+ .6	— .1

It was observed that with a given adjustment the drift of the needle was often tolerably constant, and, for a considerable period in the same direction. Sufficient additional resistance was now introduced at R. to cause the needle to drift in the opposite direction so that the influence of the radium would be exerted against the drift.

TABLE IV.

Radium added.	Radium removed.
— .7	+ .9
—1.8	+1.6
+ .4	+2.5
+3.	0
+3.	—3.

A solution of $AgNO_3$ was next used as the electrolyte. The Ag and Cu made a battery to such a degree that no consistent results could be obtained. A considerable amount of Ag was deposited on the Cu electrodes. Evidently a very dilute solution would be more likely to give results. The most satisfactory solution used was made by diluting 3 cc. of the $Cu\ SO_4$ solution used at first to 100 cc.

In Table V the radium was placed alternately upon N and S and readings taken every two minutes.

TABLE V.

Radium on S.	Radium on N.
— .6	— .8
+1.8	+2.
— .7	— .1
+1.6	— .9
— .6	+1.5

TABLE VI.

Radium on S.	Radium on N.
+ .85	— .6
+1.6	—1.15
+ .10	— 75
+ .55	— .25
+ .4	+ .5
+ .2	— .75
+ .25	— .35
+ .5	— .4
+ .15	— 05
+ .5	0
+ .4	— .5
+ .2	— .15
+ .3	0
+ .5	0
+ .35	— 2
+ .10	0
+ .06	+ .02
+ .65	+ .05
+ .15	+ .07
+ .3	— .1
+ .15	— .2
+ .15	0
+ .4	0
+ .25	0
+ .07	
+ .22	
+ .1	
.0	
+ .1	
0	
+ .1	

Several of the lists, especially Table VI, show the effect of the drift of the needle.

A number of efforts were made to overcome this difficulty, none of which were entirely successful.

One entire day was spent trying to get data for a curve which would show the influence of this ever present but very variable factor. In the first four readings of Table VII the drift was taken every five or six minutes and the succeeding readings were with the radium, readings every minute.

TABLE VII.

Time.	Deflection.	Amount of deflection.
6 min.	40.25 to 40.8	+ .17
5 min.	40.8 to 41.3	+ .5
6 min.	41.3 to 41	— .3
5 min.	41 to 41.3	+ .3

	Radium on S. Deflection.	Result.		Radium on N.	Result.
1.	41.3 to 41.6	+ .3	2.	41.9 to 41.9	0
	41.6 to 41.75	+ .15		41.9 to 42.1	— 2
	41.75 to 41.9	+ .15		42.1 to 42.1	0
3.	42 1 to 42.5	+ .4	4.	42.82 to 42.8	+ .02
	42.5 to 42.75	+ .25		42.8 to 42.75	+ .05
	42.75 to 42.82	+ .07		42.75 to 42.68	+ .07
5.	42.68 to 42.29	+ .22	6.	43 to 43.1	— .1
	42.9 to 43	+ .1		43.1 to 43.3	— .2
	43 to 43	0		43.3 to 43.3	0

If the average drift was really no greater than that obtained when special effort was made to determine its amount it was not sufficient to balance the considerable excess of positive readings.

Summary: Of the total number of readings, 61 per cent. indicated positive results, 26 per cent. were negative, and 13 per cent. were zero, i. e., gave no deflection. Of the total amount of the deflections (omitting the rather questionably large ones in Table I), 82 per cent. were positive and 18 per cent. negative. Including those of Table I, 90 per cent. were positive.