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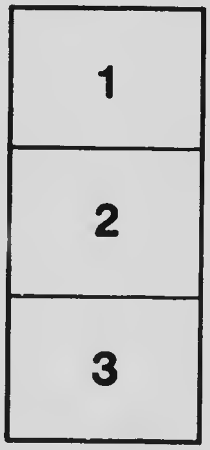

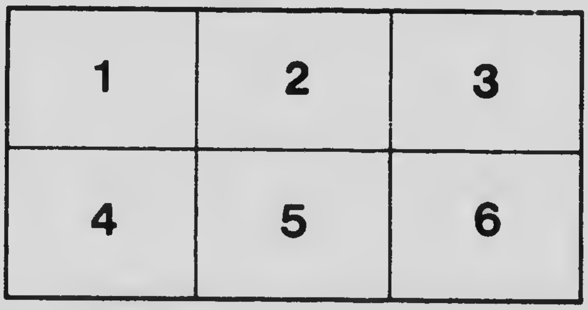

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ON THE DECAY OF EXCITED RADIOACTIVITY FROM NATURAL GASES

BY MISS L. B. JOHNSON

[Reprinted from the PHYSICAL REVIEW, Vol. XX., No. 3, March, 1905]

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ON THE DECAY OF EXCITED RADIOACTIVITY FROM NATURAL GASES.

BY MISS L. B. JOHNSON.

IN a recent paper by Professor J. C. McLennan "On the Radioactivity of Mineral Oils and Natural Gases"[2] it was shown that the natural gases of Ontario contain an emanation which is similar to that found by other investigators in the gases contained in certain spring waters and in the air drawn from the surface layers of the earth, and which, from its rate of decay as well as that of the radioactivity excited in bodies exposed to it, bears a strong resemblance to the emanation from radium.

In a paper by Miss Brooks[3] the results are presented of a series of measurements on the radiation from rods rendered radioactive by exposure to the emanation from thorium, radium and actinium. In this paper it s shown that, in the case of rods exposed for short periods to the ema- ion from thorium the radiation at first increases, reaching a maximum o about two hours after removal, and then decays according to an ex- ntial law. A similar result was obtained with rods exposed to the emanation from actinium, the only difference being that the maximum intensity with this substance is reached in about ten minutes after removal. But when the rods were exposed to the emanation from radium, it was found for all exposures that there was a rapid initial decrease in the intensity of the radiation for the first ten minutes; after which it remained constant for a length of time which decreased with the increase in the period of the exposure; then it dropped gradually and approached a zero value.

From these results it is evident that activities excited in rods by exposure to radium, actinium or thorium have certain characteristics by which they may be definitely distinguished.

The experiments described in this paper were carried out in order to examine more closely the emanation found in the natural gases mentioned above, and to throw further light on the question whether the radioactivity was due to the presence of the emanation from radium or due to the materials themselves possessing the intrinsic property of radioactivity. The behavior of the emanation was studied and a series of curves obtained showing the decay of the radiation due to the excited activity on rods exposed for different periods in the gas. It was found for all exposures that the activity dropped at first and reached a steady state which lengthened as the period of exposure was shortened. It then gradually died down to and approached a zero value. These curves are ver similar to

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society on December 30, 1904.

[2] Paper .esented at International Electrical Congress at St. Louis, September, 1904.

[3] Philosophical Magazine, September, 1904.

those given by Miss Brooks for rods exposed to the emanation from radium and, therefore, support the theory that the emanation found in the natural gases dealt with is due to the presence of radium at their source. Moreover, Professor Rutherford in his work on "Radioactivity"[1] gives results showing that the amount of activity excited on a rod exposed to the emanation from radium is always directly proportional to the amount of emanation present. To see if this was true of the active emanation in natural gases, exposures of the same period were made in the same gas on different days and it was found that, as the activity of the emanation decreased, there was always a proportionate decrease in the amount of activity which it excited.

The gas under investigation was confined in a cylinder about 60 cm. long and 25 cm. in diameter. Brass rods were suspended in the gas by insulating supports, and connected to the negative terminal of a Toepler-Holtz machine, which maintained a potential of 11,000 volts. After exposure the rods were inserted in a second receiver of the same size through which a gentle current of air was drawn in order to remove any emanation adhering to them. Their activity was then determined by means of measurements upon the conductivity they imparted to the air in the receiver. These measurements were made with a sensitive Dolezeleck electrometer, and as the rods were directly exposed to the air, the conductivity imparted by them was due to all the types of rays which they emitted.

In the paper referred to above by Professor McLennan it was shown that when measurements were made upon the conductivity of the gas as it came from the well, it exhibited a steady decrease, and fell to one half

Table I.

Conductivity of Natural Gas.

Time.		Current.	Time.		Current.
Hours.	Minutes.	Arbitrary Scale.	Hours.	Minutes.	Arbitrary Scale.
	4	288	3	41	341
	7	292	4	10	340
	15	296	5	55	327
	21	301	12	45	310
	27	307	23	20	283
	44	313	47	25	215
1		320	71	15	172
1	31	331	95	15	135
1	40	335	119		104.5
2	46	340	145		78

[1] Rutherford, Radioactivity, page 274.

value in about 2.78 days. In the present investigation the gas was studied under slightly different circumstances. As soon as it was received from the well a rod was exposed in it at different times and under negative electrification for different periods. The rod in each exposure was rendered active by the deposit of the substance causing excited radioactivity, and it was always found that the removal of the active rod was followed by a rise in the conductivity of the gas to a maximum value, after which it gradually fell according to an experimental law in the same manner as before. A typical set of observations on this variation in the conductivity is given in Table I., and a curve representing them is shown in Fig. 1.

In this case a negatively charged rod was exposed at 11,000 volts in the gas for ten hours, and it will be seen from the values given above that the conductivity steadily rose and reached a maximum value in about four hours after the removal of the negatively charged rod. It will also be seen that after the maximum value was reached the conductivity fell to one half value in about seventy hours.

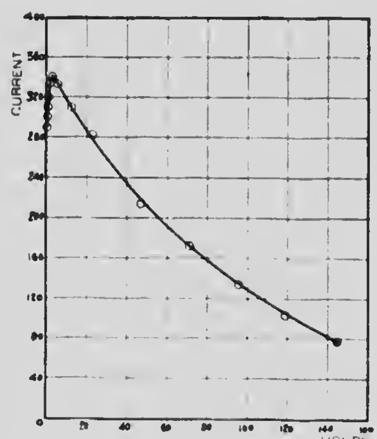

Fig. 1.

In order to investigate how the activity excited in a negatively charged rod varied with the time of exposure, a series of exposures for different periods was made on one day and the results of these observations are given in Table II. and curves illustrating them are shown in Fig. 2.

Before commencing this set of exposures a rod connected to the negative terminal of the electrical machine was suspended in the gas for about two hours. It was then withdrawn and the first exposure was made. During the intervals which elapsed between the different exposures, the electric field was always applied in the same manner to the gas, with the object of making the exposures in the presence of a freshly produced disintegration product.

The values given in Table II. and represented graphically in Fig. 2 show that for all periods of exposure the radiation decreased initially, then reached a steady state which lengthened as the period of the exposure decreased, after which it dropped steadily and approached a zero value.

TABLE II.

Two-minute Exposure.		Five-minute Exposure.		Ten-minute Exposure.		Twenty-minute Exposure.	
Time in Minutes.	Current Arbitrary Scale.	Time in Minutes.	Current Arbitrary Scale.	Time in Minutes.	Current Arbitrary Scale.	Time in Minutes.	Current Arbitrary Scale.
1	25.0	1	48.9	1	61.0	1	79.5
2	18.0	6	28.0	2	55.0	2	71.5
7	9.5	11	19.9	6	39.5	5	56.5
11.5	7.0	16	19.3	11	32.5	6	51.5
16.5	4.5	21	17.2	15	29.0	11	49.5
21.5	4.0	31	16.2	25	31.0	16	51.0
26.5	5.0	36	14.9	31	30.0	21	50.5
31	4.0	46	12.0	37	31.5	26	49.0
36	5.0	51	11.7	41	30.0	30	50.0
41	4.5	56	11.6	45	29.0	36	44.0
46	3.5	61	9.7	51	24.0	40	44.5
51	3.5			56	23.0	46	44.5
61	3.5			61	21.0	51	39.5
						56	36.5
						61	35.5

Forty-minute Exposure.		One-hour Exposure.		Two-hour Exposure.		Four-hour Exposure.	
1	125.0	4	154.3	1	196.7	1	252.3
2	122.0	7	141.3	5	174.7	4	218.3
6	102.5	11	130.8	6	173.7	17	184.3
11	96.0	20	128.8	11	163.2	35	152.3
16	91.5	25	126.3	16	154.2	42	137.3
21	93.0	30	120.3	26	148.2	52	124.3
26	90.0	35	116.3	31	141.7	60	108.0
36	82.5	40	105.8	36	134.2	65	95.3
41	76.0	45	100.8	41	126.7	69	89.5
46	73.5	50	90.8	46	113.2		
52	66.5	55	83.3	51	108.7		
56	61.0	60	78.3	56	91.7		
61	56.5			61	92.7		

These curves on account of their similarity to those of Miss Brooks for exposure in the emanation of radium form another link in the chain of evidence which leads to the conclusion that the emanation found in natural gases has radium for its source.

As stated above the results given in Table II. were obtained from observations made in one day upon the same gas. During this period as Fig. 1 shows, there was a gradual decay of the emanation. To determine the relation existing between excited radioactivity and the strength of the emanation producing it a series of exposures of five minutes duration was made on three succesive days in the same gas.

In making these measurements the conductivity of the gas was first determined, an electric field then applied as before and the exposure

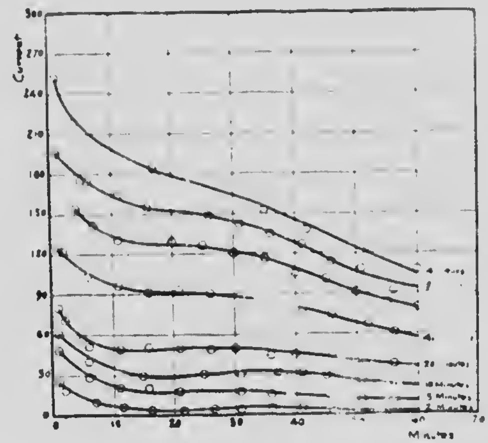

Fig. 2.

made in the gas thus treated. The same procedure was followed on each day so as to maintain as far as possible the same conditions. The results of these observations are given in Table III. which contains a record of the decay of the activity excited on each of the days.

TABLE III.

Excited Radioactivity (Five-minute Exposures).

Column I. (First Day).		Column II. (Second Day).		Column III. (Third Day).	
Time in Minutes.	Current (Arbitrary Scale).	Time in Minutes.	Current (Arbitrary Scale).	Time in Minutes.	Current (Arbitrary Scale).
1.52	110.2	1.5	90	1.5	64.5
4	70.2	9	40	2.5	55.5
5	67.2	10	32	10	24.5
10	40.2	15	30	15	27.5
15	37.2	20	35	20	28
20	38.7	24	34	25	28.5
25	39.2	30	35.6	30	28.5
31	38.8	35	31.1	35	27.5
35	38.8	40	30.1	40	25.5
40	37.3	45	30.1	45	25
45	33.8	59	26.1	55	19
50	31.3	63	23.1	60	20
55	30.3				
60	31.8				

The strength of the emanation present in the gas on each day is given in Table IV.

TABLE IV.

Exposure.	Strength of Emanation.
First day	476
Second day	394
Third day	320

From an inspection of these values together with the results in Table III. it will be seen, that a direct proportionality exists between the strength of the emanation and the amount of activity excited.

TABLE V.

Excited Radioactivity (Five-minute Exposure).

Time in Minutes.	Column I. (First Day) Current.	Column II. (Second Day) Current.	Column III. (Third Day) Current.
1	110	108	94.8
10	40.2	38.4	36
20	38.7	42	41.1
35	38.8	37.3	40.4
40	37.3	36.1	37.4
45	33.8	36.1	36.7

Table V. contains a few of the results reduced on this basis. The values of the activity obtained in the first day are recorded in Column I. and the intensity of the emanation is assumed to be unity. Columns II. and III. contain the readings obtained on the second and third days corrected to an emanation of unit intensity. The general agreement of the values recorded in the three columns justify the assumption of the law of proportionality.

In the experiments described in this paper the effects found were produced by all the rays given off from the excited body. Experiments are now in progress to investigate these effects still further and especially to determine the decay curves on the basis of β and γ radiations.

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