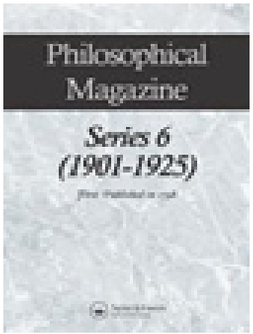

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LXV. The properites of radium in minute quantities

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If the original separation of the surfaces is less than 117 $\mu\mu$, as in the accompanying illustration, then the final distance obtained before rupture will be less than 800 $\mu\mu$.

For values of d between 0 and 730 $\mu\mu$ the curve given follows very exactly the equation

$$R = 4{\cdot}5 \times 10^{-16}\, d^6,$$

R = resistance in ohms,

d = distance between surfaces in $\mu\mu$.

It will, therefore, hardly do to assume that the conducting bridge has a uniform cross-section throughout its length. If, however, we consider it uniform when d equals 400 $\mu\mu$ and R equals 2 ohms, *i. e.* before the extension has greatly increased the resistance, then, assuming the material is pure platinum, the diameter of the bridge is found to be $4{\cdot}4 \times 10^{-5}$ cm. This distance is considerably shorter than the mercury-light waves used in this investigation, and consequently we need not be surprised at our failure to observe by microscopic examination any evidence of cohesion.

The behaviour of the coherence, however, can very readily be explained upon the assumption of the formation of a very small metallic bridge which ruptures at once upon receiving any sudden jar, causing a lateral movement, but which may be stretched until it rapidly forms a neck and breaks.

The process of the formation of the bridge is still unknown. It is probable that an explanation of the production of short spark-discharges will also make clear the coherer action. C. K.

LXV. *The Properties of Radium in Minute Quantities.* *By* A. S. Eve, *McGill University, Montreal* *.

IN a recent communication to the *Physikalische Zeitschrift* (Dec. 1, 1904), A. Voller has published some results which appear to be diametrically opposed to the theory of radioactivity, a theory which has already received a remarkable amount of experimental confirmation.

Voller found that radium, distributed on a plate in minute quantities and exposed to the air, disappeared or decayed in a few days or weeks; whereas other investigations lead to the conclusion that radium, whether in larger or smaller quantities,

* Communicated by Prof. E. Rutherford, F.R.S.

has a life of more than a thousand years. He also found that the activity of radium thinly distributed over a few square centimetres was not proportional to the mass present, but had an excess of activity very markedly greater, proportionally, in the case of small quantities. Other observers have found that in the case of the radioactive substances, and their products, the activity of a given mass is independent of the degree of concentration.

Some test experiments, made by the present writer, do not give results in agreement with those obtained by Voller, but they are in agreement with the generally accepted theory of radioactivity within the probable limits of experimental error.

The activity as measured by Voller of a small mass of radium, first dissolved in water, and then evaporated over a small area (1·2 cm.), are given in the following table :—

Amount of Radium in milligrams.	Observed Activity.
10^{-3}	38·4
10^{-4}	11·6
10^{-5}	6·2
10^{-6}	6·0
10^{-7}	3·6
10^{-8}	2·6
10^{-9}	1·6

It will be seen that on increasing the amount one millionfold the activity was increased, not one million times, but only twenty-four times.

So also for the duration of the effect, the quantities did not last for several hundred years, but disappeared in a few days, thus :—

Amount of Radium in milligrams.	Days to complete disappearance.
10^{-4}	126
10^{-5}	61
10^{-6}	26
10^{-7}	17
10^{-8}	16
10^{-9}	15

Whatever may be the true explanation of the phenomena observed by Voller, the experimental method adopted is very unsuitable as a test of the two main points under investigation.

A plate, covered with a small quantity of radium, was placed at a distance of 10 cms. from one extremity of a hollow metal cylinder, along the axis of which was an insulated rod connected with a gold-leaf system. There would thus be considerable absorption of the α rays by the air traversed, the capacity of the system would be large, and the ionization effect at the far end of the cylinder would be uncertain in character.

In the present experiments 1 c.c. of water, containing 10^{-6} milligrams of radium, was slowly evaporated over the bottom of a silvered glass flask so as to cover an area of 76 sq. cms. An ebonite cork was then carefully waxed to the mouth of the flask so that it was hermetically sealed. The ebonite supported a wire, sulphur bead, and gold-leaf system. This electroscope was charged to 300 volts when a magnet was brought near, so as to cause a small piece of magnetized watch-spring to bridge the sulphur bead insulation. The copper wire, as well as the silver coating of the electroscope, were then connected to earth. The natural leak of the electroscope had previously been determined with care for several days, and was not more than 5 per cent. of the effect under measurement.

Voller found that 10^{-6} milligrams, distributed over 1·2 sq. cm., completely disappeared in 26 days. In my experiment more than 40 days have elapsed since the maximum was reached, and I have found no trace of disappearance, in the case of 10^{-6} milligrams spread over 76 sq. cms.; and an effect of 2 or 3 per cent. could have been detected with certainty.

Experiments were also made to measure the activity produced by various small quantities of radium. Professor Rutherford kindly gave me some solutions of radium, and the required amounts were distributed by evaporation over small clean zinc or platinum dishes 4·9 .sq. cms. in area. These were then placed in the bottom of a gold-leaf electroscope having a small natural leak.

Attempts to measure 10^{-3} and 10^{-8} milligrams were not successful, as the effects on the electroscope were respectively too rapid and too slow, a result which might be expected from theoretical considerations, if the activity is proportional to the mass. In all cases the minimum values were observed, when the emanation, if present, had been driven off by evaporation, and the excited activity, if any, had time to decay; that is, two or three hours after evaporation.

A comparison of the results obtained by Voller and by

the writer is given in the following table, in which the observed activity for 10^{-4} milligrams in each case is raised to 100.

Quantity of Radium in milligrams.	Activity (Voller).	Activity (Eve).
10^{-4}	100	100
10^{-5}	53·5	10·6
10^{-6}	51·7	1·18
10^{-7}	31	·125

It will be seen that when the quantity of radium is increased one-thousandfold, Voller finds the activity increased between three and four times, whilst in the present experiment the activity is increased 800 times.

It appears desirable to remove the impression that the activity of radium in minute quantities decays in a few days. The occurrence of radium in pitchblende refutes such a suggestion.

It is also desirable to point out that the activity is at least approximately, and is probably accurately, proportional to the mass present, and that the properties of a given quantity of radioactive matter are independent of the degree of concentration.

It must be borne in mind, however, that Voller's experiments were carried out on plates exposed to the air, and the writer's experiments were entirely made in a closed vessel.

No disappearance can be detected in a closed vessel, and therefore Voller's effects cannot be due to the decay of the activity of the radium; but they may indicate a dissipation of the radium itself from the plate.

Note by Professor E. Rutherford.

The results given by Mr. Eve in this paper are supported by experiments which I have made on the radioactivity of weak radium solutions. A year ago I made up a standard solution of radium bromide containing 10^{-6} milligrams per c.c., which was kept in a stoppered bottle. The quantity of radium in a cubic centimetre of the solution, measured by the amount of emanation produced by it, has not sensibly altered in the course of a year.

A large number of experiments have been made by different observers on the rate of decay of the radioactive products, but in no case has the constant of decay of activity been

changed by altering the degree of concentration of the product. For example, the constant of decay of the radium emanation has been tested over a range of at least one million times, but no alteration of its value has been detected.

The experiments of Eve undoubtedly show that the activity of the radium bromide, *kept in a closed vessel*, after reaching its maximum, does not exhibit the decrease observed by Voller for a deposit of radium exposed to the open air. This shows that the decrease of activity, noticed by Voller, has nothing to do with the actual change in the rate of disintegration of radium, but is a result of the exposure to the open air. Not the slightest evidence has so far been obtained to indicate that the rate of disintegration of radium is in any way altered by the amount of radium present. In this respect its behaviour is analogous to the other numerous radioactive products.

On the other hand, there is some evidence that small quantities of radium, deposited on a plate by evaporation of a radium solution, apparently lose their activity fairly rapidly when left in the open air. I have observed that the activity of a plate 50 sq. cms. in area over which half a milligram of radium was deposited, lost more than half of its activity in the course of a year.

This disappearance of the activity has no connexion with the actual life of the radium itself, but is probably due to the escape of the radium from the plate into the surrounding gas. A quantity of 10^{-9} grams of radium bromide, spread over an area of 10 sq. cms., is far too small to form a layer of even molecular thickness. During the process of evaporation, the radium bromide would tend to collect together and form small crystals which are deposited irregularly over the surface of the plate. These particles would not be held firmly to the plate, and would gradually escape from it.

Such an effect would probably be also shown by inactive matter, if deposited in such minute amount. This action, however, can only be experimentally tested with a substance like radium, where the activity can be used as a means of detecting the change in an excessively minute quantity of deposited matter.

McGill University, Montreal.
March 28, 1905.