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EXPLOSION OF A RADIUM TUBE.

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In December, 1905, I received from Hugo Lieber 50 milligrams of pure radium bromide of the strength 1,800,000, just imported from Stahmer, of Berlin, and had it transferred to a small glass tube 2½ centimeters long by 3 mm. wide, in which it was hermetically sealed after drying.

It was used daily for three months, being cleansed always by immersion in carbonic acid followed by alcohol, and always handled carefully with forceps.

On March 20, on removing it from a silver tube by a thread tied about it, it stuck in the opening of the tube and I pressed it lightly with the end of the metal forceps. Instantly it exploded with a loud report, the glass being shattered into numerous small fragments, and much of the radium was distributed against the inner lining of the tube. At the same instant I saw a cloud of pulverized radium come from the tube, as large as my hand, and rather rapidly fall to the carpet, a distance of one meter.

Laying the tube carefully on a clean sheet of paper, I made a chalk outline on the carpet within which I supposed the precious powder had fallen, though nothing of it was visible. In hopes of reclaiming it, I laid a large photographic Roentgen ray plate upon the carpet, believing it would make its impression through the double paper envelope. Only one small spot showed at the corner of the plate when developed. At night I tested the carpet with a piece of willemite, which glowed brightly at a spot some distance from the suspected area, and this spot I again tested with another photograph. The resulting plate is shown on the following page.

Every smallest grain of radium made its autograph on the plate, though only a few could be seen to glow in the dark, as they had sunk into the heavy carpet.

The atomic weight of radium is so great (342) that it had fallen within the small radius of 35 centimeters, being kept together by its heaviness. I carefully cut out the piece of carpet (after testing at a distance in all directions and satisfying myself that there was no more elsewhere) and put it and the tube in the hands of Professor Pegram, of Columbia University, to reclaim the radium, if possible.

After he had beaten it out of the carpet I again gave the photographic test and was gratified to find not an atom of radium left in it.

His careful recovery of my entire specimen is described in his own words and is worthy of record. He has again sealed it in a tube of the same size, into the end of which he fused a fine platinum wire to permit the stored-up positive electricity to discharge through it, on the theory that the negative current passes out through the glass with the beta rays. This had originally been urged upon me at first sealing by my friend Dr. Piffard, but was omitted. It may now be hoped the danger of recurrence and loss will be averted. To the original 50 milligrams recovered I gave Professor Pegram 10 mg.

more to add, so that now the new tube contains 60 mg.

The danger of losing radium of so great value is not small. I quote a recent note which I have translated from the *Physikalische Zeitschrift,* Jan. 15, 1906:

"Explosion Risk of Radium." By Julius Precht, Institute of Technology, Hanover.

"On Dec. 27, 1904, I sealed in a glass tube 25 milligrams of pure radium bromide, which was finely powdered and by long heat 150° C, freed of much of its water of crystallization. The little tube was used in many experimental measurements in an ice calorimeter, and, by the end of November, 1905, was brought many times into the air and warmed to the temperature of the room.

"After it had borne these handlings seven times without accident, it spontaneously exploded suddenly with a sharp report while it was lying undisturbed in a wooden dish, three minutes after bringing it into the air. The force of the explosion was so severe that the entire glass was pulverized into almost microscopic bits, while the radium bromide was to be seen in the dark, as luminous stars on the footboards of the room. This dish was entirely free from radium. Most of it lay within one meter distance from the dish, on the floor.

"The explosive character of the event implies that it resulted from a crack in the glass with a change in temperature. Otherwise larger pieces of glass would have been found in the neighborhood. The fact of the complete pulverization of the glass shows, moreover, that a great excess of pressure was present in the tube, which after-measurement showed would take 20 atmospheres to shatter.

"Radium has its own gas—either emanation or

Autograph on Röntgen-ray plate, 28x35 cm. (11x14 inches), to locate 20 mg. ($\frac{1}{3}$ grain) radium on carpet.

helium, which changed to 20 atmospheres pressure in the tube in the course of eleven months.

"These observations will recall the phenomenon described by E. Dorn—a spark and noise, accompanied filing of a larger tube after a half-year's rest. This electric exhibition was not observed by me, but a strong smell of ozone was observed. Mme. Curie caused an explosion by heat applied to a glass tube in which radium had been sealed for two months. That explosion occurred apparently from confined gases."

Professor Pegram writes, on restoring the new tube to me:

"The material in it consists of 24.8 mgr. radium bromide recovered dry from the broken tube, 4.0 mgr. radium bromide dissolved off the tube, 10.0 mgr. radium bromide new addition, 40.0 mgr. radium bromide (impure radium bromide) recovered from the carpet. This last 40 mgr. contains about all the radium there was on the carpet. The following process was used to obtain it: The piece of carpet was tacked over a shallow box lined with paper and drummed on until free from radium by Willemite test. A considerable amount of matter was thus beaten out and caught on the paper. In the dark the bits of radium were quite evident from their fluores-

"An attempt was made to separate the soluble radium from the dirt, which was mostly insoluble, by treatment with water and filtering. The filtrate, however, contained very little radium, from which it was evident there was enough calcium sulphate *(plaster-of-Paris dust)* present to go into solution and precipitate the radium as the insoluble sulphate.

"Accordingly, the filtrate was evaporated to dryness, the residue put back with the insoluble matter, and the whole fused with sodium and potassium car-

bonates. After fusion the soluble salts were washed out, leaving the radium carbonate behind with other insoluble carbonates. These were then taken up with hydrochloric acid, the excess of acid driven off from the solution, and calcium sulphate solution added.

"Some of the radium was at once precipitated as sulphate, but to complete the precipitation the solution was left on a water bath for several hours, then allowed to cool and stand for eighteen hours. This precipitate contained the radium and any barium that was present, as sulphates, and weighed 18 mgr.

"The liquid was filtered off, the filter burned and then the sulphates fused with sodium carbonate. After fusion the soluble salts were washed out and the insoluble carbonates treated with hydrobromic acid to convert into bromides.

"The result of this was radium bromide pretty free from any impurities except barium.

"In order to save all the radium, all residues and wash water had been saved. This material was again worked through the above process, and a considerable amount of impure radium bromide obtained, iron and calcium being the chief impurities. This was put with the purer product from the first separation and no further purification attempted, as it seemed more important to obtain all the radium than to risk the losses in handling and incomplete separation.

"Throughout the work, the precipitates and residues from evaporation of solutions were examined by means of a fluoroscope consisting of a very thin layer of zinc sulphide on the underside of a piece of glass, with a lens above the glass focused on the zinc sulphide. When this was held over a layer of thorium hydroxide it was easy to see the scintillations due to the alpha rays, so with this fluoroscope it was easy to detect the presence of the slightest amount of radium or its disintegrating products in the precipitates or residues from evaporation of solutions or wash water. No material that had been in solution with the radium could be obtained entirely free from admixture of enough active material to affect the fluoroscope."

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