

## THE ATOMIC WEIGHT OF RADIUM; A NEW DETERMINATION.\*

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The determination of the atomic weight of radium which I published in 1902 (*Comptes Rendus*, July, 1902) was carried out with 9 centigrammes of radium chloride. Fresh processes having since then furnished some decigrammes of practically pure chloride, I have subjected them to purification, which enabled me to obtain 4 decigrammes of perfectly pure radium chloride, and to determine the atomic weight of radium under far better conditions than before.

The purification processes consisted as before in fractional crystallization in water containing hydrochloric acid, or in fractional precipitation of the aqueous solution by alcohol. The progress of the fractionation was controlled by photographs of the spark spectra, obtained with the spectrograph which formerly belonged to Demarcay. It is convenient to compare the relative values of the lines 4554.4 of barium and 4533.5 of radium. These lines, which are very close together, are very suitable for comparison. The line 4554.4 is the strongest in the barium spectrum, and the line 4533.5 is one of medium importance in the radium spectrum.

When the purification was stopped, the strongest barium line was still faintly visible near the other. Its complete elimination seemed to be very difficult with the quantity of material I had at my disposal. Nevertheless, I shall shortly show that the salt was very pure.

I was confronted with one difficulty during this work. When a clear solution of a radium salt is evaporated in a dish or glass, the dry sale obtained is not generally completely soluble in water, but leaves a residue. I have found that this residue is partly due to the formation of radium sulphate, in consequence of the presence of traces of sulphuric acid in the reagents (traces which could only be detected by barium salts after the concentration of the reagents), and partly to the slow action of the radium salts on the vessels. I therefore decided to prepare specially all the reagents employed. The water was distilled in a platinum still, and received and kept in a platinum flask; this water was used to prepare the hydrochloric acid, which was also kept in

\**Comptes Rendus*, 1907.

a platinum flask. The nitric acid, alcohol, and silver nitrate were also purified. It is not possible to let the radium chloride crystallize in presence of hydrochloric acid in a platinum dish, because it has considerable action on the latter. But if the clear solution is allowed to crystallize rapidly in a porcelain dish, crystals are obtained, which, after being dried, dissolve in the purified water without residue, and hence can be used to determine the atomic weight.

The method employed for this determination was the same as before. It consists in estimating as silver chloride the chloride contained in a known weight of anhydrous radium chloride. According to my earlier experiments, which were confirmed by new observations, radium chloride, which has just been prepared, loses its water of crystallization when it is heated in a drying oven above 100 deg. C., and its weight is quite constant when it has been subjected for half an hour to a temperature of 150 deg. C.

The weighings were performed with a Curie's aperiodic balance with direct reading for weights below decigrammes. This rapid balance is accurate to one-tenth of a milligramme, and takes only seconds to reach its position of equilibrium. The weighing of the radium chloride is more difficult than that of the silver chloride, because the former salt absorbs water vapor rather quickly; it is therefore essential to let it cool in a desiccator with phosphoric anhydride before weighing, and not to recommence weighing until after it has been again placed in the drying oven, even if the cage of the balance contains desiccating substances.

After each estimation the radium is present as nitrate with silver nitrate. The silver is eliminated by hydrochloric acid, and the nitric acid by repeated crystallization in presence of hydrochloric acid.

The following table gives the numbers obtained in three consecutive experiments, and the atomic weights P deduced from them, assuming that radium is a divalent metal, and that the atomic weights of silver and chlorine are:

$$\text{Ag}=107.8, \text{Cl}=35.4.$$

Radium Chloride.	Silver Chloride.	P.
0.4052	0.3906—0.00006	226.35
0.4020	0.3879—0.00006	226.04
0.39335	0.3795—0.00006	226.15
Weight of filter ash=0.00006		

The weighings of the two chlorides are considered to be exact to about one-tenth milligramme. These three experiments, which agree very closely, give for the atomic weight of radium the mean value 226.18.

The experiments, performed in 1902 with very pure radium chloride, gave less concordant results and a mean of 225. The spectrum of the salt used recently shows a rather greater degree of purity, but the difference of about one unit in the atomic weight could not be ascribed to this cause. I performed a control experiment as follows: I prepared a solution of some milligrammes of pure 1907 salt, and added to it a small quantity of a titrated solution of barium chloride. The amount of barium salt in the mixture was 0.61 per cent. In the spectrum of this salt a great increase of the intensity of the barium spectrum is shown, whereas the change of atomic weight, calculated from the known addition of barium chloride, is only 0.7 unit. From the examination of the spectra it is clear that the difference between the numbers obtained in 1902 and 1907 should be attributed only to the inferior accuracy of the experiments performed with only 9 centigrammes of radium salt and with less pure reagents.

The above experiment also proves that the spectral reaction of barium in presence of radium is very sensitive and that the radium chloride which was used for the determination must be very pure. It certainly does not contain 0.1 per cent of barium chloride.

I therefore conclude from these experiments that the atomic weight of radium is 226.2 ( $\text{Ag}=107.8$ ,  $\text{Cl}=35.4$ ) with a probable error of less than half a unit.

If the values  $\text{Ag}=107.93$ ,  $\text{Cl}=35.45$  are adopted, the value is  $\text{Ra}=226.45$ .