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POSITIVE RAY ANALYSIS OF MAGNESIUM

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In the *Physical Review* for April, 1918, I described an apparatus for positive ray analysis and gave examples of hydrogen, oxygen, sodium and potassium rays, showing that at least the lighter elements could be readily analyzed so as to separate any molecules differing in molecular weight by unity. I have recently resumed the experiments and will give in this paper an account of experiments with magnesium.

As stated in the *Physical Review* article, the experimental difficulties are largely in obtaining a steady source of the rays desired. Magnesium rays have been obtained from a piece of the metal which was heated electrically by a coil of wire, and at the same time bombarded by electrons from a Wehnelt cathode. The occluded gases are first driven off, and then the heating current is increased till the magnesium lines appear due to the metal vaporizing slightly. The positively charged molecules formed pass through a hole in a plate below the cathode and are then accelerated by a strong variable field of several hundred volts. The plate has been added to the apparatus described in the *Physical Review* to prevent the strong electrical field influencing or even inhibiting the low voltage discharge. The first slit, about 1 mm. wide, separates out a bundle of rays which is bent into a semicircle by a strong magnetic field and refocussed, if their speed is right, on the second slit, below the detecting electrode. The charge carried by the rays, which is proportional to the number of the molecules of different kinds, is measured by a Wilson electroscope used as a null instrument with a special compensating device for rapid measurements.

The charged atoms of different atomic weights are successively brought on to the detecting electrode by keeping the magnetic field constant and varying the potential which accelerates the rays, the potential required being inversely proportional to the mass of the particles. Thus, if one atomic weight is known the others may be found. Due to the finite width of the slits, each element gives a curve, on the atomic weight scale, which

is theoretically a linear increase to a maximum and then a linear decrease. The width half way to the maximum is given by $m.\ \frac{2S}{d}$ where m is the atomic weight, S the slit width and d the diameter of the circle in which the rays travel. Under good vacuum conditions this theoretical sharpness is practically obtained. For 1 mm. slits this width of the curves should thus be one-half a unit on the atomic weight scale. The former measurement with the apparatus and the magnetic field determinations sufficed to locate elements between 20 and 30 within one unit, and identified the strong nitrogen rays (possible carbon monoxide) of molecular weight 28 which are given off when the metal is first heated.

One series of experiments was as follows: After heating the magnesium slightly and pumping, till a MacLeod gauge gave no pressure indication, the nitrogen molecule was the only particle present. The heating current was then increased by steps to vaporize the magnesium. With 0.7 ampere, 28 alone was present, with 0.75 ampere an arc apparently struck as the cathode-anode current jumped suddenly to five times its value. The electron current was decreased to its former value by cooling the cathode and the rays were measured. It was found that three strong new lines had appeared. The new lines which are undoubtedly due to magnesium were compared with the nitrogen rays which were still faintly present and found to have atomic weights 24, 25 and 26. The observations are illustrated in figure 1, which gives the current or number of

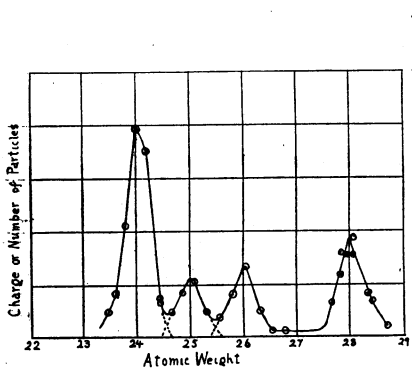

FIG. 1

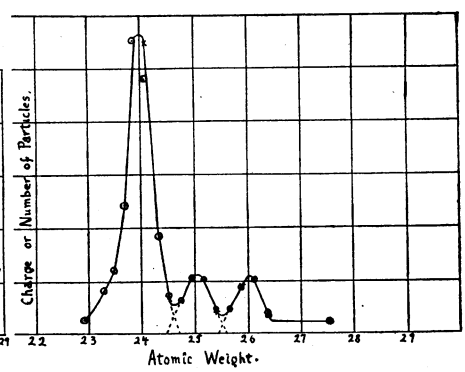

FIG. 2

particles for different atomic weights. The nitrogen line had its maximum at 817 volts, and the atomic weight abscissae are 28 × 817 divided by the volts applied. The ordinates of the 28 line are multiplied by 10 in plotting to make them comparable with the other three lines. The dotted continuation to the axis indicates the slight overlapping of the lines. We conclude that magnesium consists of three isotopes of atomic weights 24, 25 and 26.

Later curves made with steadier discharge conditions are more suitable

than figure 1 for measuring the relative strengths of the components. In figure 1 there appears to have been a drop in intensity just before 24 was reached, in the measurement from high to low atomic weights. The curve is of interest as still containing 28 faintly and so serving to accurately locate the weights which otherwise would have been uncertain to a fraction of a unit.

Figure 2 is one of several later curves taken under steadier conditions. These all have very closely the same appearance. The components 25 and 26 are present very nearly in equal amounts; in some measurements 25 was found about nine-tenths the intensity of 26. The component at 24 is approximately 6 times as strong as the one at 26. The ratio of 1 : 1 : 6 gives an average atomic weight 24.375, which is in as good agreement with the accepted atomic weight for magnesium as could be expected with the wide slits used in these first experiments.

THE ENERGY CONTENT OF THE DIAPASON

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In *Science*, **52**, 1920 (586–8), I indicated a method by which the intensely luminous achromatic fringes could be used, without further mechanism, to determine the compression in the interior of a sounding organ pipe.

Meanwhile Profs. A. T. Jones, of Smith College, and H. F. Stimson, of the Bureau of Standards, have called my attention to papers of Boltzmann (*Pogg. Ann.*, **141**, p. 321) and Raps (*Wied. Ann.*, **50**, p. 193) and to some work of Stimson himself, which I had overlooked. These researches make most of my work superfluous. I will, therefore, confine myself to a few special features, as the interferometer which I set up, admitting of any separation of the interfering beams, longitudinally or laterally, is better adapted for work of this character than the Fresnellian fringes or the Jamin interferometer used heretofore. Two opposed nodes may be examined simultaneously. Moreover the ease with which fringes of any size or inclination are producible is a further advantage.

As the transformations are adiabatic, the density increment $\Delta\rho$ at any time is of the form $\Delta\rho = C.n\lambda/lR$, if n fringes of wave-length λ are displaced when the ray passes through a pipe of length l. R is the gas constant and

$$C = \frac{p_0}{\vartheta_0(\mu_0 - 1)} = 10^7 \times 1.27$$

the optic constant when p_0 and ϑ_0 are standard pressure and absolute temperature, and μ_0 the corresponding index of refraction of air. Thus the mean mechanical energy per cm.^{3} is $p\,\Delta\rho/\rho$ for the length l surveyed,