The Relative Abundances of the Zinc and Cadmium Isotopes

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April 2, 1948

TWELVE years ago one of us[1] reported values for the relative abundances of the zinc and cadmium isotopes. Since that time numerous improvements have been made in mass spectrometry. Thus, in view of the present-day interest in more accurate nuclear constants it appeared worth while to repeat some of the early work. In the new work we employed a 60° mass spectrometer similar to one already described.[2] Compounds having a negligible vapor pressure at ordinary temperatures could be volatilized by a small oven built into the ion source.

In the investigation of zinc, ZnI_2 was employed and measurements were made for the ZnI_2^+, ZnI^+, and Zn^+ ions. Although the fractional spread in masses varied from approximately 2 percent for ZnI_2^+ ions to 10 percent for Zn^+ ions, no systematic differences in the abundance ratios in the three positions could be observed, so it could be concluded that any discriminatory effects in the instrument were negligible. Table I shows the results obtained.

TABLE I. Isotopes of zinc.

	Mass number				
% Abundance	64	66	67	68	70
Present work	48.89	27.81	4.07	18.61	0.620
Earlier work[a]	50.9	27.3	3.9	17.4	0.5

[a] See reference 1.

The numbers given are the averages for the ZnI_2^+, ZnI^+, and Zn^+ spectra, each weighted equally. The calibrations and consistency of the results lead us to believe that the abundance ratio of any pair of isotopes is accurate to within one percent. With a packing fraction of -7.0 and a conversion factor of 1.000275 in going from the atomic to the chemical scale a chemical atomic weight of 65.40 is computed. This is to be compared with the chemical value 65.38.

In cadmium, ions CdI_2^+, CdI^+, and Cd^+ were investigated. Table II gives the results. As in zinc the numbers

TABLE II. Isotopes of cadmium.

	Mass number							
% Abundance	106	108	110	111	112	113	114	116
Present work	1.215	0.875	12.39	12.75	24.07	12.26	28.86	7.58
Earlier work[a]	1.4	1.0	12.8	13.0	24.2	12.3	28.0	7.3

[a] See reference 1.

given are the averages found for the three types of ions. Here, too, we believe any discriminatory effects to be sufficiently small to state that the abundance ratio of any pair of isotopes is accurate within one percent. A packing fraction of -6.0 yields a chemical atomic weight of 112.42, which is to be compared with the chemically determined value 112.41.

These data indicate that the mass spectrometer as employed in the early work must have discriminated against ions of different mass sufficiently to give an error as large as 20 percent in the abundance ratio of the most widely separated isotopes of zinc and cadmium. That an error should have existed is perhaps not surprising since the primary purpose in the earlier work was to obtain very high resolution so that rare isotopes could be detected. Thus extremely narrow slits were employed. As we now know, these conditions can lead to abnormal discrimination.

The instrument used in this work was built with a grant from the Graduate School. This research was supported by Navy Contract N5ori-147, T. O. III, between the Office of Naval Research and the University of Minnesota. Material assistance was also given by the University of Minnesota Technical Research Fund.

[1] A. O. Nier, Phys. Rev. **50**, 1041 (1936).
[2] A. O. Nier, Rev. Sci. Inst. **18**, 398 (1947).

The Isotopic Composition of Xenon

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April 6, 1948

WEFELMEIER, in a paper on the exceptional relations between the nuclei of samarium,[1] pointed out that the proportion in which the isotopes of xenon occur is abnormal, too. He suggested that this irregularity should be explained by a transition of four xenon isotopes to tellurium either during or shortly after the formation of our present atomic nuclei. However, we are now in a position to understand that the peculiar situation in xenon has a much more trivial cause.

It is a well-known fact that nuclei with even atomic weight are found in nature in larger concentrations than nuclei with odd atomic weight, because of the difference in binding energy between these two types of nuclei. Thus, if in one element three isotopes occur with consecutive mass numbers—two even ones and one odd one—the concentration of the odd one is always less than the sum of the concentrations of the even ones. The only exception—and a very striking one—is xenon, where Xe^{129} is more than four times as frequent as its two neighboring isotopes together. In this element the percentages of the isotopes have been observed as follows:[2] Xe^{124}: 0.094 percent; Xe^{126}: 0.088 percent; Xe^{128}: 1.90 percent; Xe^{129}: 26.23 percent; Xe^{130}: 4.07 percent; Xe^{131}: 21.17 percent; Xe^{132}: 26.96 percent; Xe^{134}: 10.54 percent; Xe^{136}: 8.95 percent. It is evident from these figures that everything would be normal if the concentration of Xe^{129} were about ten times smaller.

It has repeatedly been pointed out that by far the larger part of the noble gases, which originally accompanied the material of the earth, have been lost from our atmosphere, probably during the earliest part of its history.[3] This theory explains the insignificant quantities of the other noble gases compared with argon. At present this element consists almost entirely of A^{40}, the isotope which was formed by K-capture in K^{40} after most of the original noble gases had disappeared.[4]