This work was supported in part by the University Research Committee with funds made available by the Wisconsin Alumni Research Foundation.

[1] R. T. Overman, Abstracts Am. Chem. Soc. Meeting 111, p. 44P, paper 70 (1947).
[2] D. Grahame and H. Walke, Phys. Rev. **60**, 909 (1941).
[3] U. S. Atomic Energy Commission Isotopes Catalog No. 2, Item 16. The sample used in this work was of much higher specific activity than the standard sample listed in the catalog and had been chemically purified from S^{35} formed by the $Cl^{35}(n, p)S^{35}$ reaction. With unpurified samples a high background of bremsstrahlung from the intense S^{35} beta-radiation is observed.
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Magnetic Multipole Internal Conversion

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THE use of the ratio of the K to L shell internal conversion coefficients has been suggested for determining the multipole nature of radiation emitted from the atomic nucleus.[1] Curves showing the values of this ratio as a function of energy for $Z=35$ have been given for electric multipoles[1] valid for the region of low energies.

To facilitate the comparison with the experimental data, it is desirable to have curves for the magnetic multipole case valid in the same region of energy. This has been accomplished by using for the K shell a rigorously correct expression specialized to the case of non-relativistic energies for the magnetic multipole internal conversion, due to Bessey,[2] based on the Dirac equation, and an analogously derived formula for the L shell internal conversion. Figure 1 shows curves for the K to L ratio evaluated for $Z=35$ in the magnetic multipole case taking into account screening as in Hebb and Nelson. For the sake of comparison, the curves of Hebb and Nelson for the electric case are included. The Hebb and Nelson curve for $l=4$ has been omitted, whereas for the experimental application, this must of course be used with the $l=3$ magnetic case.

The K to L ratios for the magnetic multipole radiation have been previously calculated by the Born approximation[1,3] for use with the K to L electric multipole low energy curves. For comparison of the relative values of the magnetic multipole ratios in the two approximations, we have shown in Fig. 2 curves for the Born approximation as well

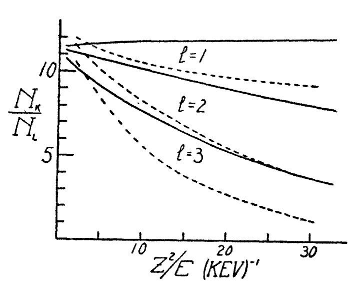

Fig. 1. Curves for N_K/N_L as a function of Z^2/E. Solid line—magnetic multipole, broken line—electric multipole.

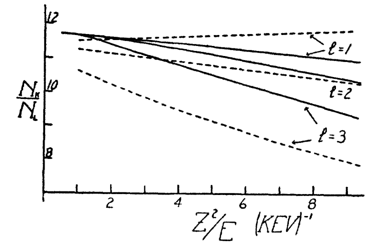

Fig. 2. Curves for N_K/N_L for magnetic multipoles as a function of Z^2/E. Solid line—Born approximation, broken line—Pauli approximation.

as those mentioned above for the rigorous low energy case. From these curves it appears that the Born approximation ratios for $l=1$, 2 differ from our low energy approximation by less than 10 percent in the neighborhood of 10^5 ev, and greater, gamma-ray energy. However, it should not be concluded that the K and L magnetic internal conversion coefficients, β_K and β_L, calculated in the two ways agree that well. For example, for $l=1$ and 2×10^5-ev gamma-ray energy the difference in the β_K's so determined is approximately 15 percent and in the β_L's approximately 12 percent. For $l=3$ it is clear that the difference in the ratios for the two approximations is appreciably larger than for $l=1$, 2. Consequently, caution is required in assuming equivalence of the two approximations for the ratio in this energy range in the general case, at least for $Z=35$ and higher.

Finally the L shell electric multipole conversion has been calculated in the region of low energies, starting from the Dirac equation, to ascertain whether additional contributions from the spin might alter the value for this quantity as determined by Hebb and Nelson using Schroedinger theory. The answer is in the negative.

In conclusion, we wish to express our gratitude to Dr. J. R. Bessey for sending us the correct expression for the low energy K conversion in the magnetic case[4] before publication and to Professor G. E. Uhlenbeck for his kind interest in this work.

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[4] The results of G. Goertzel and I. S. Lowen, Phys. Rev. **67**, 203 (1945) and of V. Berestetzky, J. de Phys. U.S.S.R. **10**, 137 (1946), using the elementary Pauli theory for the K shell, while in agreement with each other, are incorrect owing to failure of the simple Pauli theory which does not take into account correctly contributions from the origin in the case of the highly singular magnetic multipole potentials. See reference 2.

O^{17} and S^{36} in the Rotational Spectrum of OCS*

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THE transitions $J=1\rightarrow2$ of $O^{16}C^{12}S^{36}$ and $O^{17}C^{12}S^{32}$ have been detected. Abundance and mass of S^{36} were determined. The spin of S^{36} appears to be zero, and there is some indication that the spin of O^{17} is $\frac{1}{2}$.

S^{36} was discovered by Nier[1] who stated its abundance as 1:6000, so that a very sensitive spectrograph was needed

TABLE I. Measured OCS lines.

Transition	Molecule	Standard	Frequency interval between standard and measured line (Megacycles)	Frequency (Megacycles)
J 1→2	$O^{17}C^{12}S^{32}$	$O^{16}C^{12}S^{34}$	196.62±0.04	23534.67
J 1→2	$O^{16}C^{12}S^{36}$	$O^{16}C^{12}S^{34}$	532.63±0.04	23198.66
J 1→2 $V_1=1$	$O^{16}C^{12}S^{34}$	$O^{16}C^{13}S^{34}$	14±1	23661

TABLE II. Relative intensity measurements.

Molecules	Measured intensity ratio	Relative abundance	Relative abundance from Segrè chart
$\frac{O^{16}C^{13}S^{34}}{O^{17}C^{12}S^{32}}$	1.26±0.05	1.25±0.05	1.26
$\frac{O^{17}C^{12}S^{32}}{O^{16}C^{12}S^{36}}$	2.84±0.14	2.71±0.14	2.34

to detect its line in OCS near 1.3-cm wave-length. A Stark modulation system[2] was used with a modulation frequency of 50 kc and a 10-ft. wave-guide absorption cell cooled to −78°C to enhance intensities. The detected signal was fed through a phase detecting or "lock in" amplifier to an Esterline-Angus recording ammeter, giving a narrow band width for elimination of noise. A clock motor varied the signal oscillator uniformly in time so that the ammeter pen of the recorder produced a spectral plot. The marking pen was connected to a frequency measuring system similar to that used with oscilloscope presentation[3] so that frequency markers could be set on a line to a reproducibility of about 0.02 mc. Relative abundances of isotopes were determined by comparison of heights of recorded lines with crystal current, gas pressure, and Stark voltage kept constant. Relative abundances were obtained from these relative heights after a small correction was made to allow for variation of absorption intensity with frequency.

An OCS^{36} line is shown in Fig. 1. Its absorption coefficient is 7×10^{-9} cm^{-1} at room temperature, and it may be seen that a line of intensity 5×10^{-10} cm^{-1} would be approximately equal to noise deflection, so that the spectrograph can detect even rarer isotopes. A modulation frequency of 200 kc decreases noise considerably, but did not appreciably increase sensitivity because of other types of variations.[4]

The $O^{17}CS$ and OCS^{36} lines were examined closely with half-widths of about 1 mc and no hyperfine components found, indicating that the quadrupole coupling constants in both cases are less than 5 mc. Since eqQ for OCS^{36} is known to be 28.5 mc, this is a good indication that the spin of S^{36} is zero. However, since eqQ for O^{17} might be expected to be small, even with a spin of $\frac{3}{2}$, the small value of eqQ does not justify a definite conclusion that the spin of O^{17} is $\frac{1}{2}$.

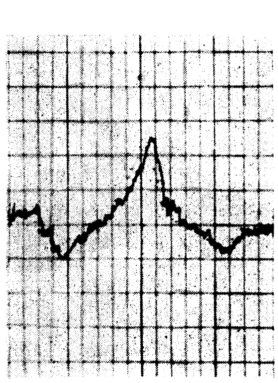

FIG. 1. OCS^{36} $J=1\rightarrow2$ transition. Undisplaced line is represented by a peak in center and Stark components $M=0$ and $M=1$ by valleys on the right and left, respectively.

Measured frequency intervals and line frequencies calculated from them are given in Table I. From these figures and published frequencies for other isotopes the ratio of mass differences $(O^{17}-O^{16}/O^{18}-O^{17})=1.00420$ and $(S^{36}-S^{34}/S^{34}-S^{32})=1.001826$ are obtained.[5] The first figure agrees well with the value $(O^{18}-O^{17}/O^{17}-O^{16})=1.004098$ from Segrè.[6] If the microwave data were used to evaluate the mass of O^{17}, the value obtained would differ only 0.00005 mass unit from the accepted mass. The ratios obtained for the sulfurs, combined with other measurements of S^{32} and S^{34} masses,[7] allow a determination of the mass difference $S^{36}-S^{34}=2.00055\pm0.0003$ and hence the hitherto unmeasured S^{36} mass as 35.97834 ± 0.0004 m.u.

Relative abundances and intensities are given in Table II. The $(O^{16}C^{13}S^{34}/O^{17}C^{12}S^{32})$ ratio agrees very well with previous measurements, but the ratio $(O^{17}C^{12}S^{32}/O^{16}C^{12}S^{36})$ disagrees slightly more than the error ±10 percent given by Nier[1] for his ratio of 1:6000 for the abundance of S^{36} to S^{32}. The present measurement gives an abundance for S^{36} of 0.0136±0.0010 percent or 1:7000 relative to S^{32}.

* Work supported by the Signal Corps.
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On the Geiger-Nuttall Relationship

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THE Geiger-Nuttall relation, $\log\lambda=a+bE$, which has played a fundamental part in the understanding of nuclear phenomena, is modified and refined in the present work. It is shown that instead of plotting the isotopes of each radioactive series as is usually done,[1] the relationship will be valid and the curve will be a smooth one only when isotopes of same atomic number are plotted, as suggested by Berthellot.[2]

The theoretical background of this assumption is as follows. Assuming the potential barrier near a nucleus to be the result of an inverse square field up to a distance r_0 and a rectangular hole for distance less than r_0, the transparency of the potential barrier for α-particles, as calculated by A. K. Saha,[3] is $T=2e^{-2K}$. With semiclassical argu-

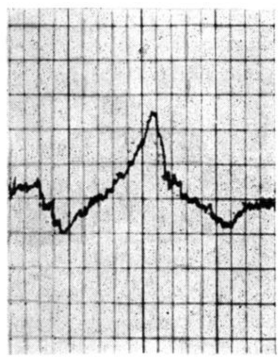

FIG. 1. OCS^{36} $J=1\rightarrow 2$ transition. Undisplaced line is represented by a peak in center and Stark components $M=0$ and $M=1$ by valleys on the right and left, respectively.