

largely of very soft electrons of 1.5 mg/cm² half-thickness in Al, along with possibly a small amount of unconverted gamma-radiation and probably x-rays. The half-period and character of the radiations possessed by this 43 isotope suggest that its activity is the same as that observed by Cacciapuoti and Segrè⁴ from the deuteron bombardment of molybdenum.

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¹ B. N. Cacciapuoti and E. Segrè, *Phys. Rev.* **52**, 1252 (1937).

² G. T. Seaborg and E. Segrè, *Phys. Rev.* **55**, 808 (1939).

³ W. H. Sullivan, N. R. Sleight and E. M. Gladrow, private communication (see Plutonium Project Report CC-1493, March 8, 1944).

⁴ B. N. Cacciapuoti, *Phys. Rev.* **55**, 110 (1939).

Electrical Conductivity of Na-Ammonia Solutions at Low Temperatures

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R. A. OGG¹ has observed that the electrical resistance of approximately one-molar sodium solutions in liquid ammonia decreases when rapidly frozen, so that the resistance of solid solutions is very low compared with the resistance of liquid solutions. Moreover, experiments carried out with an adaptation of the classical "ring experiment" in magnetic field, induced Ogg to think that these solutions may act as superconductors up to 180°K.

With successive experiments, Boorse *et al.*,² and Daunt and co-workers,³ could not confirm the existence of superconductivity. Hodgins,⁴ on the contrary, reports that four trials, of the numerous ones he carried out, gave positive results.

Some experiments on superconductivity and measurements of resistance carried out by us, seem to contribute

to the clarification of this phenomenon. The solutions we used were approximately of one-molar concentration and were prepared by dipping into purified ammonia, glass ampoules containing sodium which had been just broken. The rapid freezing of the solutions was obtained by the falling of a small quantity of solution into a small glass having a thin plane bottom, previously immersed in the liquid air. Immediately on the bottom of the glass a solid disk was formed which in a few seconds reached the temperature of the liquid air. This operation was performed between the pole pieces of an electromagnet capable of providing a field of about 500 gauss. Afterwards the glass was rapidly extracted and brought near a magnetometer whose sensitivity was about 10⁻⁴ gauss. The duration of this last operation was of the order of one second. To avoid too rapid heating of the solid disk, a plush disk was applied on the bottom of the glass which could remain saturated with the liquid air. Twenty trials gave negative results. It is to be assumed that the disk was often broken during the freezing, which evidently, however, could not entirely prevent the circulation of eventual persistent currents.

Measurements of resistance of the solutions at different temperatures have been carried out, while they were progressively frozen or heated. The cell containing the solution was constructed from a small glass on whose bottom two strip platinum electrodes connected with a Wheatstone bridge, in which a resistance was continuously variable, were disposed, and the soldering of a very thin copper-constantan couple was protected from the ammonia by a little bed of white wax.

More or less rapid freezing or heating of the solution may be obtained by simple artifices. By not too rapid freezing or heating (the time necessary for the solidification or melting of the disk was of the order of one minute), it was noted that the variation of the resistance as a function of the temperature is similar to Fig. 1, which refers to one particular experiment with a 0.7 molar solution.

Evidently the resistance of the liquid solution increases very rapidly near the solidification temperature. Below this temperature a sudden decrease of resistance was observed, to a value much smaller than the one attained by the liquid solution. This phenomenon is reversible with the temperature. In the particular case shown in Fig. 1, the ratio of maximum resistance to minimum resistance is about 150, and it is to be supposed that with still slower freezing or heating this ratio might become greater. Evidently, as the solution solidifies, the resistance decreases very much. The increase of resistance which is noted immediately above this temperature is probably owing to the fact that, in the proximity of the solidification point, two liquid phases can be formed. With very rapid freezing, on the contrary, one may not note the increase of resistance which precedes the solidification, or only a very small increase may be noted. This probably occurs because solid and liquid phases are contemporaneously present but not in thermal equilibrium, and therefore it is to be assumed that the true range of this phenomenon does not depend on the velocity of freezing.

We could not measure very exactly the resistance of the solid at the temperature of the liquid air because, in the

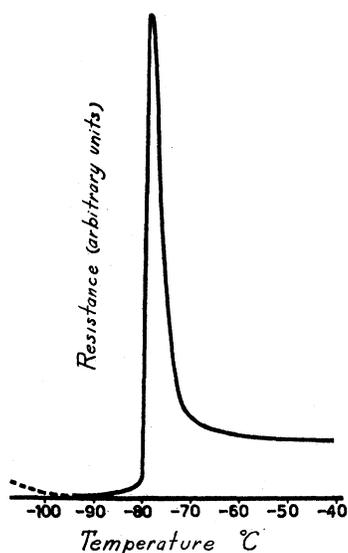


FIG. 1. Typical resistance curve of sodium-ammonia solution in the neighborhood of the solidification temperature.

greatest number of cases, even a little below the solidification temperature cracks were formed in the disk, thus falsifying the measurements and causing an illusory increase of resistance. In the luckiest cases the resistance at the temperature of the liquid air was found to be almost equal to that of the solid just below the solidification point.

There was still the possibility that the solid resistance was much lower than the one measured with this method, because of the resistances in the contacts. Therefore measurements with a potentiometer method were carried out. The resistance of the solid also was always found with this method and so in all our experiments the phenomenon of superconductivity was absent. On the other hand, the fact which we demonstrated, that the sudden decrease of resistance occurs just at the solidification point, induces us to think rather of a phenomenon depending just on the change of state, than of a phenomenon of superconductivity.

¹ R. A. Ogg, *Phys. Rev.* **69**, 243 (1946).

² H. A. Boorse, D. B. Cook, R. B. Pontius, and M. W. Zemansky, *Phys. Rev.* **70**, 92 (1946).

³ J. G. Daunt, M. Désirant, K. Mendelssohn, and A. J. Birch, *Phys. Rev.* **70**, 219 (1946).

⁴ J. W. Hodgins, *Phys. Rev.* **70**, 568 (1946).

Relative Abundance of the Copper Isotopes and the Suitability of the Photometric Method for Detecting Small Variations in Isotopic Abundance

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USING a Dempster double-focusing mass spectrograph,¹ the abundance ratio of the two copper isotopes was determined photometrically with a view to ascertaining the value of the method in detecting small variations in isotopic abundances. Following the general method of Mattauch and Ewald,^{2,3} the blackening curve of Ilford Q11 plates was obtained by using as standards the isotopes of zinc, which have been accurately measured by Nier.⁴ A brass rod served as one of the electrodes in a Dempster spark source⁵ and provided both zinc and copper ions. The intensities of the mass spectrum lines were measured with a microphotometer, and a blackening curve was drawn for each photographic plate. On most plates there were more than one exposure and, in these cases, the blackening curve was drawn with considerable certainty.

The values of the ratio $\text{Cu}^{63}/\text{Cu}^{65}$ obtained by measurement of twenty-one mass spectra are listed below:

2.258	2.335	2.242	2.284	2.135
2.292	2.433	2.160	2.342	2.400
2.296	2.215	2.010	2.425	2.392
2.145	2.370	2.342	2.362	2.230
		2.142		

These data lead to a mean value of the ratio $\text{Cu}^{63}/\text{Cu}^{65} = 2.277 \pm 0.017$, the probable error being based on the internal consistency of the experimental results. The manner in which the present blackening curves were obtained, namely, in most cases by use of two or more zinc spectra of varying intensity, tended to cancel out small errors in

the presumed abundance of the zinc standard. Consequently the isotopic constitution of copper is $\text{Cu}^{63} = 69.48 \pm 0.16$ percent and $\text{Cu}^{65} = 30.52 \pm 0.16$ percent. Flugge and Mattauch⁶ give a value for the packing fraction of $\text{Cu}^{63} = -8.13 \pm 0.10 \times 10^{-4}$, while Duckworth⁷ gives $\langle f \rangle_{\text{AV}}$ for Cu^{63} and Cu^{65} to be $-7.92 \pm 0.25 \times 10^{-4}$. Assigning a value of $f = -8.03 \pm 0.10 \times 10^{-4}$ to both copper isotopes, and using the ratio given above, namely, 2.277 ± 0.017 , one obtains a chemical atomic weight of 63.542 ± 0.006 . This is not in very good agreement with the accepted chemical atomic weight⁸ of 63.57 but does agree splendidly with the recent value of 63.542 obtained by Hönigschmid and Johannsen.⁹ Ewald's latest value³ for the $\text{Cu}^{63}/\text{Cu}^{65}$ ratio is 2.330 ± 0.032 .

Some remarks should be made regarding the efficacy of the method for detecting small variations from the natural abundance. If enough of the sample material is available to make, say, ten determinations of the type described above, the probable error in the ratio would be of the order of 0.020. Since there is associated with the natural ratio a probable error of 0.017, variations would "probably" (used in the probable error sense) be real if they exceeded $0.037/2.277 = 0.016$ of the natural ratio. As the measured ratios diverged still further from the natural value, the certainty of the variation being a real one would increase in the statistical manner. With the present accuracy the method would not be useful for variations from the natural abundance of less than about one-half percent.

These measurements were made while the authors were at the University of Manitoba. The senior author gratefully acknowledges the support of the National Research Council of Canada. The authors were ably assisted in the experiment by Miss Constance Cox, a senior student in physics at the University of Manitoba.

¹ A. J. Dempster, *Proc. Am. Phil. Soc.* **75**, 755 (1935).

² J. Mattauch and H. Ewald, *Zeits. f. Physik* **122**, 314 (1944).

³ H. Ewald, *Zeits. f. Physik* **122**, 487 (1944).

⁴ A. O. Nier, *Phys. Rev.* **50**, 1041 (1936).

⁵ A. J. Dempster, *Nature* **135**, 542 (1935).

⁶ S. Flugge and J. Mattauch, *Physik. Zeits.* **44**, 181 (1943).

⁷ H. E. Duckworth, *Phys. Rev.* **62**, 19 (1942).

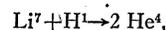
⁸ *J. Am. Chem. Soc.* **63**, 850 (1941).

⁹ O. Hönigschmid and T. Johannsen, *Naturwiss.* **31**, 548 (1943).

Angular Distribution of the $\text{Li}^7(p, \alpha)\alpha$ Reaction

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MEASUREMENTS of the angular distribution of the 8-cm alpha-particles produced in the reaction



have been made for the range of proton energy from 400 to 1400 kev. Approximate agreement with previous work^{1,2} up to 900 kev is observed, but there is only a gradual decrease in the asymmetry from 800 to 1400 kev.

The apparatus used was a scattering camera,³ similar in principle to that described by Chadwick, *et al.*,⁴ using photographic detection of the emitted alpha-particles. Figure 1 shows the apparatus schematically. The $2'' \times 4''$