A Mass-Spectrographic Study of the Isotopes of Silicon

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The isotopic constitution of silicon has been studied by Aston[1] and photometrically by McKellar.[2] In the work reported here a Nier[3] type mass spectrometer was used to measure the relative abundance of the silicon isotopes. The vapor studied was SiF_4. Of the positive ions formed by electron impact in SiF_4, the SiF_3^+ group has the greatest intensity. For this reason, measurements were made of the ion peaks at mass numbers 85, 86, and 87. A typical mass spectrum is shown in Fig. 1. The values obtained for the abundances were: Si^{28} 92.24±0.10; Si^{29} 4.69±0.05; Si^{30} 3.07±0.05. The present values, together with those of McKellar are shown in Table I.

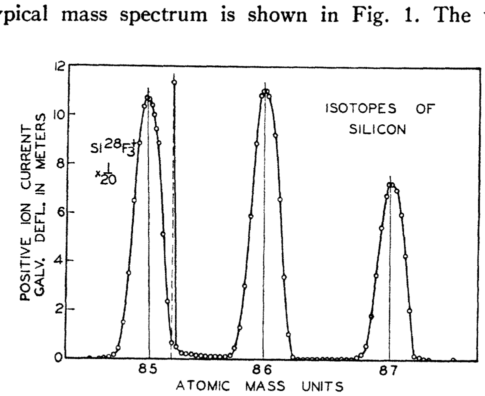

Fig. 1. Mass spectrum of silicon. $Si^{28}F_3$ has been plotted to 1/20 scale. Ion current is in meters deflection at highest sensitivity. One meter corresponds to about 10^{-12} ampere.

Table I. Isotopes of silicon.

Investigator	Percent abundance Si^{28}	Si^{29}	Si^{30}
Present work	92.24	4.69	3.07
McKellar	89.6	6.2	4.2

A search was made for rarer isotopes. None was found, and the following upper limits for the abundances relative to Si^{28} were set: Si^{25}, 1/10,000; Si^{26}, 1/3000; Si^{27}, 1/10,000; Si^{31}, 1/20,000; Si^{32}, 1/50,000; Si^{33}, 1/50,000. Using packing fractions[4] of -4.86×10^{-4} for Si^{28}, -4.54×10^{-4} for Si^{29}, and -5.79×10^{-4} for Si^{30}; and the conversion factor of 1.000275 in going from the physical to the chemical mass scale, we find for silicon the atomic weight 28.087. This is in substantial agreement with 28.06, the chemical atomic weight. The writers take pleasure in acknowledging their indebtedness to Professor A. O. Nier at the University of Minnesota.

[1] Aston, *Mass Spectra and Isotopes* (Edward Arnold and Company, London, 1933).
[2] A. McKellar, Phys. Rev. **50**, 761A (1934).
[3] A. O. Nier, Rev. Sci. Inst. **11**, 212 (1940).
[4] H. E. Duckworth, Phys. Rev. **62**, 19 (1942).

The Occurrence of Superconductivity in a Collective Electron Assembly

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It was suggested by Frenkel[1] that magnetic interaction between currents might cause the free electrons in a metal to freeze into a rigid lattice, and he gave qualitative reasons for supposing that such an assembly might move through a crystal without loss of energy and so account for superconductivity. Bethe and Frölich,[2] however, showed that there would in fact be no significant decrease of resistance.

Frenkel in fact assumed without proof that the potential

$$\sum_{ij} e^2u_iu_j/r_{ij} \tag{1}$$

would itself ensure that all the speeds u_i would become equal at sufficiently low T, so that the energy of the electrons would be

$$\sum_{ij} e^2u^2/r_{ij}. \tag{2}$$

It is here suggested that a more strategic way of simplifying (1) would be to average the effect of all the other electrons upon any given electron by writing

$$\gamma I=\sum_j eu_j/r_{ij}, \qquad \text{any } i, \tag{3}$$

so that in place of (2) we would have

$$\sum_i \gamma eu_iI, \tag{4}$$

where I is the total current in the specimen. The contribution of a single electron with speed u in the direction of the current would then be γeuI per cm path, and the perturbation to be used in the Boltzmann equation becomes

$$\pm\gamma eu^2\tau I, \tag{5}$$

where τ is the time of relaxation for the speed u. It can then be shown that in an ideal crystal the Sommerfeld statistical theory leads simply to the result

$$I=\mathrm{E}/(R-\gamma\bar{u}), \tag{6}$$

where E is the e.m.f., R is the ideal resistance, and $\bar{u}$ the electron velocity corresponding to the top of the Fermi limit. The effective resistance thus vanishes when the ideal resistance drops to the value $\gamma\bar{u}$.

This theory, although exceedingly crude, makes superconductivity the analog of ferromagnetism. The current plays the same role as spontaneous magnetization in the Heisenberg theory, and the constant γ takes the place of the simple exchange energy term in the Stoner modification of Heisenberg's theory.

In a paper to appear shortly[3] in the *Proceedings of the Cambridge Philosophical Society*, the writer proposes and examines a model of a superconductor as an aggregation of ideal domains within each of which the above formulae apply, and it is shown that the correct diamagnetic behavior automatically accompanies the superconducting transition and also that the transition temperature depends on the magnetic field in the correct manner.