fired ceramics and the single crystal samples in either orientation, although the electron mobility in the crystals is somewhat smaller in the *a* than in the *c* direction. The observed mobilities in all cases were low.

R10. Effect of Impurity Content on the Specific Heat of Germanium.* I. Estermann and J. R. Weertman, *Carnegie Institute of Technology.*—It has been reported[1] that the specific heat of Ge has an anomaly at 80°K. Since Ge forms a monatomic lattice of the diamond type, it was difficult to associate the excess specific heat with any known lattice process. Preliminary measurements of the specific heat curve of Ge carried out by one of us in 1944 on a pure Ge sample failed to show the reported anomaly. New measurements with much higher precision were carried out with a very pure and a less pure sample of 10^{20} impurity centers per cm^3. The results show that the excess of specific heat of the impure over the pure sample is no more than the order of one percent. No anomaly of the type reported by Simon and Critescu was found.

* Assisted by the ONR and the Research Corporation.

[1] S. Critescu and F. Simon, Z. physik. Chem. (B)**25**, 273–282 (1934).

R11. The Photo-Voltaic Effect of Survace $P-N$ Barriers in Germanium. B. J. Rothlein, *Sylvania Electric Products, Inc.*—Surface barriers on germanium can be made having an exceptionally high photo-voltaic response. These barriers can be used as a cell possessing high signal to noise ratio owing to their use at zero current. The shape of the spectral response curve at room temperature is similar to what has previously been reported for germanium;[1] the decay in response with increased chopping frequency, however, appears somewhat greater. The characteristics of this effect will be described.

[1] M. Becker and H. Y. Fan, Phys. Rev. **78**, 301 (1950).

R12. Germanium Rectifier Characteristics. R. N. Hall, *General Electric Research Laboratory.*—Rectifiers made from purified germanium wafers whose opposite faces are strongly doped with donor and acceptor impurities have electrical characteristics which follow a simple theoretical formula over a current range extending from the saturation reverse current to several hundred amperes per cm^2 in the forward direction in the temperature range between 200° and 400°K. Since the region in which holes and electrons recombine is the well-defined volume between the impurity layers, the calculation of the diode current is not difficult and is given by

$$I=(q\, ln/\tau)[\exp(qv/2kT)-1].$$

The high purity region has a thickness l, while n and τ are the concentration and lifetime of the carriers in intrinsic germanium. The factor of $\frac{1}{2}$ in the exponential results from the use of a volume recombination rate which is essentially linear in the concentrations of holes and electrons. The rectifier characteristics indicate that the direct recombination of holes and electrons, which varies as the product of their concentrations, becomes appreciable only at very high forward currents. The experiments give a volume recombination time for the linear process of 0.0002 sec at room temperature, while the lifetime for direct recombination is of the order of 0.03 sec.

R13. Motion of Vacancies in a One-Dimensional Homogeneous Lattice. Yü-Chang Hsieh* and I. Bloch, *Vanderbilt University.*—An atom in a perfect crystal is assumed to be in a stationary one-dimensional potential well. When one of its neighbors is removed, the atom finds itself in a wider well with a "hump" in the middle; its wave function then becomes a wave packet which moves back and forth between the two lattice sites. The motion of this wave packet is related to the coefficient of diffusion of "holes" in the lattice, and hence to the coefficient of self-diffusion of the substance composing the lattice. This crude model indicates that even at low temperatures "holes" diffuse rather rapidly, because of the tunnel effect.

* Now at Purdue University, Lafayette, Indiana.

R14. Photo-Conductivity of Trapped Electrons in the Alkali Halides. J. J. Oberly, *Naval Research Laboratory.*—The photo-conductivity of the color center bands (*F*, *R*, *M*, *N*, *S*) associated with trapped electrons in alkali halide crystals has already been reported.[1] Quantitative measurements have now been made at room temperature on crystals irradiated with soft x-rays to obtain the relative photo-current per absorbed photon for the various types of centers. This relative response is proportional to the quantum yields if the ranges (Schubwege) of the electrons freed from the various centers are the same. In KBr all of the bands are found to be photo-conductive after their formation by x-rays or by optical bleaching of other bands. However, both the F- and M-bands can be made relatively non-photo-conductive by bleaching them with F- and M-light, respectively. The "soft" fractions of the bands which bleach readily are the photo-conductive portions, while the residual "hard" absorption is caused by non-photo-conductive centers. The peak absorption wavelength of the hard F centers is slightly shorter, corresponding to the B-band of Petroff. The hard type of center has not been observed for the other bands which is an indication of the similarity of the F- and M-bands on one hand and of the R- and N-bands on the other.

[1] J. J. Oberly and E. Burstein, Phys. Rev. **79**, 217 (1950).

Friday Afternoon at 2:15

Shoreham, Main Ballroom

(A. O. Nier presiding)

Nuclear Masses, Abundances, and Magnetic Moments

RA1. Atomic Masses in the Region About Mass 40. T. L. Collins, Alfred O. Nier, and Walter H. Johnson, Jr., *University of Minnesota.*—The double-focusing mass spectrometer already described[1] has been used to measure masses of isotopes near $M=40$ by the doublet method, comparisons being made with hydrocarbons. H^1 and C^{12} were taken as 1.008165 ± 4 and 12.003842 ± 6, respectively.[2] The isotopes measured and the packing fractions ($\times10^4$, all negative) computed were as follows: S^{33}, 5.41; S^{34}, 6.24; Cl^{35}, 5.71; Cl^{37}, 6.03; A^{36}, 5.83; A^{38}, 6.59; K^{39}, 6.12; K^{41}, 6.10; Ca^{40}, 6.60; Ca^{43}, 6.36; Ca^{44}, 6.99; Ca^{48}, 6.72; Sc^{45}, 6.62. The probable errors varied between 0.01 and 0.02. Fluctuations from nuclide to nuclide follow approximately those predicted by the Bohr-Wheeler formula except about Ca^{40} and Ca^{48}, where the nuclides are actually somewhat more stable than the formula predicts. The discrepancy is especially marked for Ca^{48}.

[1] A. O. Nier and T. R. Roberts, Phys. Rev. **81**, 507 (1951).
[2] A. O. Nier, Phys. Rev. **81**, 624 (1951).

RA2. Masses of Th^{232} and U^{238}. GEORGE S. STANFORD AND HENRY E. DUCKWORTH, *Wesleyan University.**—The mass spectrograph has been used to photograph doublets at mass number 58 consisting of singly-charged Fe^{58} and quadruply-charged Th^{232}, at mass number 116 consisting of singly-charged Sn^{116} and doubly-charged Th^{232}, and at mass number 119 consisting of singly-charged Sn^{119} and doubly-charged U^{238}. The following packing fraction differences were measured: Th^{232}—Fe^{58}, $\Delta f=13.17\pm0.06$: $Th^{232}-Sn^{116}$, $\Delta f=9.89\pm0.03$: and $U^{238}-Sn^{119}$, $f=10.24\pm0.03$. Using the known packing fractions[1] of Fe^{58}, Sn^{116}, and Sn^{119} of -8.43 ± 0.07, -5.30 ± 0.05, and -4.79 ± 0.05, respectively, the packing fraction of Th^{232} is found to 4.64 ± 0.10 from the Th−Fe comparison, 4.59 ± 0.06 from the Th−Sn comparison, and that of U^{238} is found to be 5.45 ± 0.06. The corresponding masses are $Th^{232}=232.1070\pm0.0012$ and $U^{238}=238.1297\pm0.0015$. Some remarks will be made concerning the agreement between these mass values and that[2] of $Pb^{208}=208.0422\pm0.0015$ on the basis of radioactive decay data.

* Supported by the AEC.

[1] To be published.

[2] H. E. Duckworth and R. S. Preston, Phys. Rev. (to be published).

RA3. Masses of Xe^{129} and Xe^{132}. CORT L. KEGLEY AND HENRY E. DUCKWORTH, *Wesleyan University.**—The mass spectrograph has been used to photograph a triplet at mass number 43 consisting of singly-charged C_2OH_3 and C_3H_7 and triply-charged Xe^{129}, and a second triplet at mass number 44, consisting of singly-charged CO_2 and C_2OH_4 and triply-charged Xe^{132}. The following packing fraction differences were measured: $C_3H_7-Xe^{129}$, $\Delta f=20.15\pm0.02$; $C_2OH_3-Xe^{129}$, $\Delta f=11.68\pm0.025$; $C_2OH_4-Xe^{132}$, $\Delta f=13.08\pm0.025$; CO_2-Xe^{132}, $\Delta f=4.90\pm0.02$. Using the masses[1] $H^1=1.008147$ and $C^{12}=12.003794$, the packing fractions of Xe^{129} and Xe^{132} are computed to be -4.23 ± 0.02 and -3.99 ± 0.05, respectively, corresponding to the masses $Xe^{129}=128.94543\pm0.00026$ and $Xe^{132}=131.94733\pm0.00066$. It is hoped that masses will also be reported for Kr^{82}, Kr^{84}, and Kr^{86}. Typical mass spectra will be shown.

* Supported by the AEC.

[1] K. T. Bainbridge (private communication).

RA4. Nuclear Reaction Energies and Nuclear Masses as Integral Multiples of a Natural Unit of Mass and Energy. ENOS E. WITMER, *University of Pennsylvania.*—About a year ago the writer pointed out that one-eleventh of the rest mass of the negative electron appeared to be a natural unit of mass and energy for nuclei and elementary particles not subject to β-decay. This unit of mass and energy was designated *the prout.* Furthermore, it was pointed out that the neutron and many other nuclei subject to β-decay appeared to follow the integral rule. Recently, "Energy levels[1] of light nuclei, III" appeared, giving a more accurate and extensive set of values for nuclear reaction energies. These data as well as other recent data support the hypothesis stated above very well. These results are self-consistent, so that it is possible to make a table of nuclear masses in prouts up to about Ne^{20}. Because of the slight uncertainty in M_p/m this has been done both with 20196 prouts and 20197 prouts as the proton mass. In the second case the nuclear masses in prouts are A prouts larger. But the *nuclear masses in mass units* differ only in the sixth or seventh decimal places in the two cases, since O^{16} is standard.

[1] Hornyak, Lauristen, Morrison, and Fowler, Revs. Modern Phys. 22, 291 (1950).

RA5. A New Method for the Measurement of the Isotopic Abundance of Solids. H. SOMMER AND J. A. HIPPLE, *National Bureau of Standards.*—Several measurements of isotopic abundance have been made on a modified Dempster mass spectrometer to demonstrate a method of using electrical detection with a high frequency vacuum spark source. The use of electrical detection is made possible by measuring the ratio of the selected ion current to a representative sample of the total ion current produced by the spark source. Although the emission from the source fluctuates erratically owing to the nature of the spark, the observed ratio remains essentially constant. The successful use of this instrument for quantitative analysis of solids has been previously described.[1] Tentative results of the measurement of the isotopic abundance of nickel, copper, and magnesium yield values with accuracies comparable to other recently published results. For example, the value obtained for the isotopic abundance of copper in atom percent is: $Cu^{63}=68.94\pm0.26$; $Cu^{65}=31.06$. The results obtained for magnesium agree closely with those of Hibbs and Redmond.[2]

[1] Gorman, Jones, and Hipple, to be published in Anal. Chem.

[2] R. F. Hibbs and J. W. Redmond, Carbon and Carbon Chemicals Corporation Report Y-290, November 24, 1948.

RA6. Hyperfine Structure of Te^{123} and Te^{325}. JOHN S. ROSS AND KIYOSHI MURAKAWA, *University of Wisconsin.**—Hyperfine structure spectrograms obtained with a liquid-air cooled hollow-cathode source using enriched isotopes show that the Te^{125} *I* line $\lambda 2530.7(5p^4\,{}^3P_1-5p^36s\,{}^5S_2)$ consists of two components 0.113 cm^{-1} apart, the shorter frequency being the stronger. Thus, the magnetic moment of Te^{125} is negative, since Te^{125} and Te^{123} are known to have spin $\frac{1}{2}$. The line $\lambda 2385.7(5p^4\,{}^3P_1-5p^36s\,{}^3S_1)$ was found to be single to an accuracy of 0.03 cm^{-1}. Using these data and appropriate hyperfine structure formulas,[1] the value $\mu(Te^{125})=-0.74\pm0.20$ n.m. was obtained. From the large splitting of the Te *II* lines λ5449 and λ5311 the ratio μ^{125}/μ^{123} was found to be $1.188\pm.010$, which gives the result $\mu(Te^{123})=-0.62\pm0.20$ n.m. This indicates that both nuclei are probably in an $S_{\frac{1}{2}}$ state, which is in agreement with the prediction of Mayer's nuclear shell theory.

* Supported by the ONR.

[1] M. F. Crawford and L. A. Wills, Phys. Rev. 48, 69 (1935).

RA7. Hyperfine Structure of Tungsten.* JOHN A. VREELAND AND KIYOSHI MURAKAWA, *University of Wisconsin.*—The hyperfine structure of the tungsten spectrum was examined with a Fabry-Perot etalon, using two samples enriched in W^{180} and W^{183}, respectively. The structure of W^{183} in more than twenty-five arc lines was measured, and the splittings of more than twenty terms determined. The value of the magnetic moment of W^{183} was found to be $+0.08\pm0.02$ n.m. The isotopic displacement effect in the arc lines gave $\Delta(W^{186}-W^{184}):\Delta(W^{184}-W^{182}):\Delta(W^{182}-W^{180})=1.00:1.13\ (\pm0.01):1.02\ (\pm0.02)$.

* Supported by the ONR.