TABLE I. Comparison of theory and experiment.

		Lattice constant (10^{-8} cm)		Compressibility at $T=0°$ (10^{-12} cm²/dyne)		Infra-red wave-length (10^{-4} cm)		Tensile strength at $T=0°$ (10^{10} dyne/cm²)
Without van der Waals correction	Calc. by Jensen	3.96	8.0%	15.5	82.4%	215	66.6%	—
	Calc. here	3.79	3.4%	9.57	12.6%	82	36.4%	2.63
With van der Waals correction	Calc. by Jensen	3.84	3.5%	13.0	52.9%	195	51.2%	—
	Calc. here	3.69	0.7%	8.47	0.4%	124	3.9%	1.52
Experimental values		3.67		extrapol. to $T=273°$: 9.4. lin. extr. to $T=0°$: 7.6. mean value: 8.5		129		—

The whole calculation was not performed according to the Gombás model, but the results were obtained with the aid of a perturbation method from Jensen's results, leading to great simplifications in the numerical evaluations. The two corrections mentioned above give a perturbation term in each of Jensen's second and third energy terms. The new state of equilibrium is given by the vanishing of the derivative of the total lattice energy obtained in this way. Supposing the correction in the lattice constant to be small, which is verified by the results, the new lattice constant can be written as $\delta_0'=\delta_0+\Delta\delta_0$, where δ_0 is Jensen's lattice constant. Neglecting terms of the second or higher order in $\Delta\delta_0$ we get

$$\Delta\delta_0=-\frac{(d\Delta E/d\delta)_{\delta=\delta_0}}{(d^2E/d\delta^2)_{\delta=\delta_0}+(d^2\Delta E/d\delta^2)_{\delta=\delta_0}},$$

where E is Jensen's lattice energy and $\Delta E=E'-E$ is the energy change, E' being the new lattice energy. We get the value of $(d^2E/d\delta^2)_{\delta=\delta_0}$ in this expression from the compressibility calculated by Jensen (see Table I), since

$$(d^2E/d\delta^2)_{\delta=\delta_0}=18\delta_0/\kappa,$$

κ being the compressibility at zero absolute temperature. Detailed calculations must be made to evaluate $(d\Delta E/d\delta)_{\delta=\delta_0}$ and $(d^2\Delta E/d\delta^2)_{\delta=\delta_0}$. This can be done as follows. Gombás' ν' can be introduced by an additive term $\delta\nu=\nu'-\nu$ to the electron density, ν, of Jensen. $\delta\nu$ can be approximated very well as a linear function of r in the range important here, i.e., in the outer parts of the ions, and the Jensen densities also can be approximated well by analytical functions in the same region. So the integrals concerned can be evaluated in closed form, which in the present case is more advantageous than numerical evaluation.

In the accompanying table my results are compared with those of Jensen and with the experimental values. For each theoretical value the percentage deviation from the experimental value is given. Taking into account the expression for the van der Waals energy given above, the results are in excellent agreement with the experimental values even for such sensitive properties as the compressibility or the infra-red frequencies. This good agreement would not be disturbed even by a smaller change in the approximating expression used for the van der Waals energy. I have calculated the tensile strength of the crystal with respect to a uniform dilatation also, but these results cannot be compared with the observed value, since the last is a structure-sensitive property, while the former was calculated on the basis of a structure-insensitive model.[4]

Detailed calculations will be published elsewhere.

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Isotopic Assignment of Cd and Ag Activities

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THE author has reported[1] that the 6.7 hr. Cd and the long-lived Cd of 158-day half-life, K-capture activities formed by the reaction Ag(d, $2n$)Cd, both decay to isomeric states of Ag, both of which have half-lives of 40 sec. and decay by the emission of γ-rays of 93 kev and 87 kev, respectively. The fact that the γ-rays are distinct was checked by observing the K and L conversion lines of both on a single photograph in a β-ray spectrograph[2] and noting that on successive photographs the 93-kev lines disappeared with the 6.7 hr. half-life. Bradt, Gugelot, Huber, Medicus, Preiswerk, and Scherrer[3] confirmed this result and in addition report that the 93-kev isomeric state has a half-life of 44.3 sec., the 87-kev. state of 40.5 sec.

The purpose of this letter is to report the isotopic assignment of these activities. In this laboratory a group under the direction of Dr. Burton Moyer has prepared approximately 100 mg. samples enriched in Cd^{106} and Cd^{108}. Mass spectrographic analysis showed the former to be 58.3 percent Cd^{106}, 0.6 percent Cd^{108}, and the latter to be 0.7 percent Cd^{106}, 45.4 percent Cd^{108}. The remaining percentages of each sample contained the other Cd isotopes in approximately their normal ratio. Through the kindness of Dr. Moyer the author was able to bombard these samples with slow neutrons from the 60″ cyclotron. The 6.7-hr. period was the predominant activity in the 106 sample after a few hours bombardment. A three-week bombardment produced in the 108 sample a weak, long-lived activity with absorption curve characteristic of the 158-day Cd. These two activities are easily identified by absorption curves of their electrons since the only electrons emitted (except for the rare positrons found by Bradt *et al.*) are the conversion lines with range about 10 mg/cm². The results then assign the 6.7 hr. Cd to Cd^{107}, the 93-kev isomer to Ag^{107}; the 158-day Cd to Cd^{109}, and the 87-kev isomer to Ag^{109}. A deuteron bombardment of normal Ag showed that the Cd isotopes are formed in roughly equal numbers as would be expected from the roughly equal abundances of the Ag isotopes. The Cd^{109} assignment was further checked in the following way. If Ag is bombarded with α-particles, Cd^{107} is formed only by the reaction (α, $p3n$), while Cd^{109}

is formed both by this reaction and the more probable (α, pn). Bombardment of Ag with approximately 40 Mev α-particles produced a good yield of the long-lived Cd, a small or possibly zero yield of the 6.7 hr. Cd. This latter yield will be further checked.

The bombardment of Ag with approximately 20-Mev deuterons also produced in the surface layers of the target a Pd activity of 13 hr. half-life. Rall[4] has assigned this activity to Pd^{109}, so in this case it is formed by the reaction $Ag(d, 2p)Pd$. An absorption measurement gave 1.0 Mev as the upper limit of the β-spectrum, in satisfactory agreement with the 1.08 Mev reported by Kraus and Cork.[5] The threshold of the reaction is $E_{max}+2M_H-M_D$ or about 2.5 Mev. However, the low probability that protons be ejected through the barrier with low energy explains the fact that Krishnan[6] with 9-Mev deuterons observed no Pd activity, and that the yield here was observable only at high bombarding energies. No other Pd activity was found. Pd^{107} must have a very short half-life to have escaped detection in other investigations, or a half-life greater than 25 years to be undetected in this case.

I wish to thank Dr. Moyer for the use of the enriched samples and Dr. J. G. Hamilton and the members of the 60″ cyclotron crew for the bombardments.

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Beta- and Gamma-Ray Energies of Several Radioactive Isotopes*

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October 24, 1946

THE thin magnetic lens spectrometer constructed by Wilkinson and Rall at the Metallurgical Laboratory and now in use at Clinton Laboratories has been used to obtain data on the beta- and gamma-ray energies of several additional radioactive isotopes.

All activities were produced by slow neutron irradiation of the elements or their compounds in the Clinton pile. All samples, with the exception of the dysprosium compound, were spectroscopically analyzed for impurities. In no cases did the combination of factors, such as amount of impurity, cross section of impurity for slow neutron capture, and period of any activity due to the impurity, appear to be such that the impurity could be responsible for any observed gamma-rays.

Table I summarizes the results obtained. The gamma-ray energies are probably correct within 2 percent except where the approximation sign indicates less reliable data. The last column gives rough estimates on the relative intensities of gamma-rays from most of the isotopes. These may be in error by as much as 50 percent.

TABLE I. Energies of beta- and gamma-rays.

Isotopes	Beta-ray End points (Mev)	Gamma-rays (Mev)	Rel. intensities of gamma-rays
26.8 hr. As^{76}		0.57	5
		1.25	2
		1.84	very weak
		2.15	very weak
24.1 hr. W^{187}	0.6 and 1.3	0.48	3
		0.69	2
14.1 hr. Ga^{72}		0.64	1
		0.84	6
		2.25	6
26.5 d. Cr^{51}		0.32	
18 hr. Re^{188}		0.16	4
		0.48	1
		0.64	2
		0.94	2
		1.43	1
51.5 d. $Hg^{203 \text{ or } 205}$	<0.3	0.28	
40 hr. La^{140}		0.335	1
		0.49	10
		0.83	20
		1.63	100
		~2.3	5
46 hr. Sm		0.11	
		~0.6	
60 d. Sb^{124}	0.53 and 2.25		
2.8 d. Sb^{122}	1.36 and 1.94		
11 d. Ge^{71}	~0.6[a]	~0.5[b]	
67 hr. Mo^{99}		0.24[c]	
		0.75	
2.5 hr. Dy^{165}		0.37[d]	
		~1.0	

[a] Probably positrons.
[b] Possibly annihilation radiation.
[c] Preliminary data; no chemical separation, but these gamma-rays are probably not from 6.1-hr. activity of element 43. Data indicate that other gamma-rays may also be present.
[d] Preliminary data; other gamma-rays may also be present.

Details of these studies will appear in the *Volume of Collected Papers on Nuclear Physics of the Plutonium Project Record.*

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The Abundance of He^3 in Atmospheric and Well Helium

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December 2, 1946

BY means of a 60° mass spectrometer we have just completed an investigation of the relative abundances of the helium isotopes. The average value for the He^4/He^3 ratio in two samples of atmospheric helium from the Air Reduction Sales Company was found to be 9×10^5,[1] and that for two samples of well helium 7×10^6. These values should not be in absolute error by more than 25 percent. The relative He^3 concentrations are within 10 percent. The He^3 peak was completely resolved from HD. In all cases the He^4/He^3 ratio was independent of pressure and amount of hydrogen impurity. The ionization efficiency curve for the He^3 peak agreed within experimental error with that for He^4 and was distinctly different from that for HD.

Alvarez and Cornog[2] have reported the existence of He^3 as a result of observation of a mass three beam in the Berkeley 60″ cyclotron and gave He^4/He^3 ratios of 10^8