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92

New Short–Lived Isomers in the Millisecond Range

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WE have investigated isomeric states with half–lives in the millisecond range which resulted from interactions with 20 mev protons. In addition to previously observed isomers,[1] data have recently been obtained concerning new isomeric radioactivity in a number of elements.

The method of investigating short–lived activities was described in our previous article.[1] In the present measurements, the γ–energy was determined by the use of a FEU–19 photomultiplier with a (2.9 × 1.6 cm) NaI (Tl) crystal and single–channel differential analyzer. For each γ–energy measurement the spectrometer was calibrated by the Cr^{51} line (E_γ = 0.33 mev, $T_{1/2}$ = 26.5 days). In addition, the accuracy of the apparatus was controlled by the γ–emission which results from proton irradiation of Ta ($T_{1/2}$ = 5.5 ± 1.0 m sec)[1,2].

The Table contains our average values for the half–lives and energies of the observed γ–radiation. The errors are the mean deviation of results in different experiments.

In some cases we used control targets consisting of different chemical compounds which contain a given element. The half–lives measured in compounds of a given element are in good mutual agreement.

After we had obtained the data in the Table, information concerning a few short–lived isomeric radioactivities was published in the literature. These findings can be compared with our own values.

Softky[2] showed that the γ–emission with E_γ = 0.305 mev which accompanies K capture in Se^{75} has the half–life $T_{1/2}$ = 18.0 ± 1.5 m sec. and must be assigned to an isomeric state of As^{75m} The short–lived radioactivity which we obtained from proton irradiation of Ge has a half–life and an energy which agree with the corresponding values for the γ–emission of As^{75m} ($T_{1/2}$ = 17.5 ± 2.0 m sec, E_γ = 0.310 mev) and must result from the reaction Ge^{76} (p, $2n$) As^{75m} with

Target	$T_{1/2}$ m sec	E_γ, mev	Data from other authors		Suggested reaction
			$T_{1/2}$, m sec	E_γ, mev	
Ge	17.5±2.0	0,31	18±1.5[3] 14[4]	0.305 [3] 0.315 [4]	Ge^{76} (p, $2n$)As^{75m}
$SrCO_3$	16.5±2.0	0.41±0.02	—	—	—
Y_2O_3	13	0.20±0.02	—	—	—
Zr	10±1	0.24±0.02	10÷20[5]	0.250 [5]	$Zr^{90}(p, n)Nb^{90m}$
SmO	A few m sec	—	—	—	—
HgO	42±5	0.37±0.02	—	—	—
	5±1	—	—	—	—
Ga	несколько мсек	—	—	—	—
Cd	47±10	0.28	45±10[6]	0.312±0.01 [6]	Cd (p, n) или Cd(p, $2n$)

$\sim$ 13 mev threshold. Our data on Ge radioactivity is also in good agreement with the values obtained for As γ–emission after irradiation in the 22–mev betatron.[4]

The short–lived radiation from Zr ($T_{1/2}$ = 100 ± 1.0 m sec, E_γ = 0.24 ± 0.02 mev) can be assigned to an isomeric transition of Nb^{90m} [reaction (p, n) with threshold $\sim$ 12 mev], because our values for the half–life and energy of the transition are in good agreement with the corresponding values for Nb^{90m} ($T_{1/2}$ = 10–20 m sec, E_γ=0.250 mev) which result from the β^+ –decay of Mo^{90} [5].

When Zr was irradiated, in addition to the radioactivity with $T_{1/2}$ = 10.0 ± 1.0 m sec we detected a shorter–lived activity with $T_{1/2} \sim 0.6$ m sec as well as a longer–lived activity with $T_{1/2} > 10^{-1}$ sec.

Our earlier article[1] reports the isomeric radioactivity which results from the irradiation of cadmium with fast protons ($T_{1/2}$ = 40 ± 10 m sec). In connection with the abstract,[6] which reports isomeric radioactivity in indium ($T_{1/2}$ = 45 ± 10 m sec, E_γ = 0.312 ± 0.010 mev) after irradiation with 22–mev γ–rays, it can be assumed that the radioactivity which we had observed in cadmium was the isomeric radioactivity of indium resulting from a (p, n) or (p, $2n$) reaction on a cadmium isotope.

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93

Negative Ions of Silicon, Germanium, Tin and Lead

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IN continuing the study of negative atomic ion production we looked for such ions of elements in the right–hand column of the fourth group of the periodic table. For one of these elements, carbon, negative ions had been found[1,2]. In the present work we established the existence of negative atomic ions of the remaining elements in the subgroup IV *B*: Si, Ge, Sn and Pb.

The negative ions were produced in an ion source through the interaction of an electron beam with molecules of a halide of the element under investigation. We also obtained negative ions by "charge exchange", that is, by the transfer of an extra electron from donor ions to atoms of the investigated substance[3]. For the purpose of analyzing and recording the negative ions, we used a magnetic mass spectrometer with resolving power sufficient to separate the isotopes of lead. In order to obtain the line intensities needed for measurements of the negative ion spectrum, it was necessary to maintain a higher vapor density of the working substance in the ion source than had been sufficient for the recording of positive pions, and also to use stronger electron currents in the ionization chamber. Both of these factors somewhat reduced the resolving power of the mass spectrometer for negative ions.

We now outline the experimental details and results for the individual elements.

Silicon. The ion source contained $SiCl_4$ vapor. The electron energy in the ionization chamber was 60 ev and the electron beam current was 6 mA. In the negative ion spectrum we observed the following groups of lines: Si^- (28,29,30), Cl^-, $SiCl^-$, Cl_2^-, $SiCl_2^-$, $SiCl_3^-$ and $SiCl_4^-$. The Si^- lines were easily identified by comparison with the Cl^-(35,37) lines and from the peak ratios for the isotopes with masses 28, 29 and 30. The dissociation and ionization of $SiCl_4$ molecules by electron impact was studied by Vought[4]; for low $SiCl_4$ vapor density in the ion source the negative ion spectrum revealed only Cl^- and $SiCl_2^-$ ions. Bates [5], who