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INTERACTION OF ACCELERATED NITROGEN NUCLEI WITH BISMUTH

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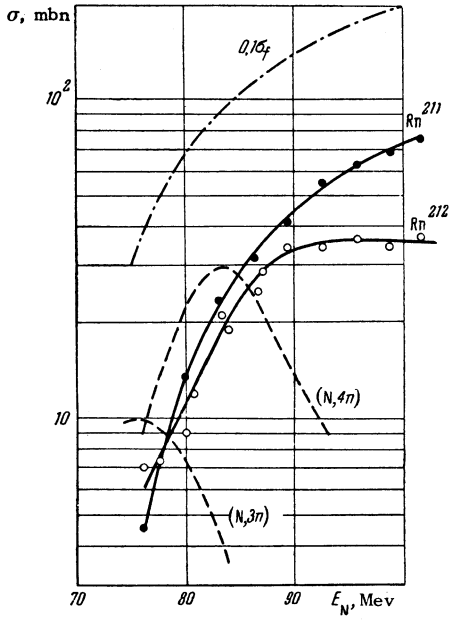
We have investigated reactions that lead to the production of α-active isotopes upon interaction of accelerated N^{14} nuclei with bismuth. A stack of ten layers of bismuth (~ 0.8 mg/cm^2 each), deposited on thin nickel foils ($\sim 1.5\,\mu$) was exposed in the internal beam of the cyclotron to nitrogen ions with energies of ~ 102 Mev. The foils were attached to a special sampler in front of the current collector, to control the ion current to the target during the irradiation process. The nitrogen ions lost approximately 3 Mev upon passing from one layer of bismuth to another. The results of Oganesyan[1] were used to calculate the deceleration of the ions. To avoid overheating the target, the current did not exceed 0.01 μa.

Using a luminescent α-particle counter insensitive to the β and γ background, we investigated in detail the decay of the activity induced in the bismuth layers. The α-particle energy was measured with an ionization chamber (emitters 1 and 2) and a photoemulsion (emitter 3). We were thus able to establish the production of the α emitters, the characteristics of which are indicated in the table (emitters 4 and 5 were not investigated in detail).

α-emitter	1	2	3	4	5
T	15±2 hr	25±2 min	150 days	2—3 min	5—7 hr
E_α, Mev	5.7±0.2 7.3±0.2	6.1±0.2	5.2±0.3		

The first α activity must be quite unambiguously ascribed to Rn^{211} ($T = 16$ hours, $E_\alpha = 5.82$ Mev) and to the At^{211} ($T = 7.5$ hours, $E_\alpha = 5.89$ Mev) and Po^{211} ($T = 0.5$ sec, $E_\alpha = 7.43$ Mev) which are in equilibrium with it. Emitter 2 is obviously also a radon isotope — Rn^{212} ($T = 23$ min, $E_\alpha = 6.23$ Mev). It must noted that Rn^{209}, Rn^{208}, and Fr^{212} do not differ greatly from Rn^{212} in the half-lives and energies of the α particles. However, estimates show that the contribution of these isotopes into the observed activities is small. The Rn^{209} may be the result of α-decay of Ra^{213} ($T = 2.7$ min), which is the product of the reactions (N, 6n) and (N, α6n). From the yield of the α emitter with half-life of 2 — 3 minutes we can surmise that, for nitrogen ions with energy 100-Mev (which, obviously, corresponds to the maximum probability of the reaction with emission of six neutrons), Rn^{209} can cause not more than 5 or 10% of the observed activity with a half-life of 25 minutes. The contribution of Rn^{208} and Fr^{212} should be even less, since reactions with emission of not less than seven nucleons would be necessary for their appearance.

The dependence of the cross sections for the production of Rn^{212} and Rn^{211} on the energy of the nitrogen ions is shown in the diagram. The



relative course of the curves is determined, essentially, by statistical errors, which do not exceed 10%. The inaccuracy in determining the absolute value of the cross sections is on the order of 50%. It is connected with the errors that arise

in the measurement of the thickness of the bismuth layer, of the intensity of the beam, and of the efficiency of the α-particle counter. The diagram indicates also the cross section σ_f for the fission of the compound nucleus Th^{223}, which is almost identical with the cross section for its production.[2]

The isotopes Rn^{212} and Rn^{211} may result from α-decay of the reaction products, with emission of neutrons only, (N, 3n) and (N, 4n), and may also be due to reactions with emission of α particles, (N, xα3n) and (N, xα4n), where x = 1 or 2. The dependence of the cross sections for the production of Rn^{212} and Rn^{211} on the energy of the nitrogen nuclei makes it possible to ascertain which one of these reactions is the more probable. The diagram shows (dotted) the calculated curves for the cross sections of the reactions (N, 3n) and (N, 4n). The cross sections are given in arbitrary units. It has been assumed in the calculations that $\sigma_{xn}(E) \sim \sigma_c(E) w_{xn}$, where $\sigma_c(E)$ is the cross section for the production of a compound nucleus by nitrogen ions with energy E, while w_{xn} is the probability of evaporation of x neutrons at a corresponding excitation energy of the compound nucleus.[3] Comparison of the experimental and calculated curves leads to the conclusion that the reactions (N, 3n) and (N, 4n) can give a decisive contribution (> 50%) to the yield of Rn^{212} and Rn^{211} only at nitrogen-ion energies less than 78 and 86 Mev, respectively. At large energies the yield of this isotope is obviously determined by the reactions of type (N, xα3n) and (N, xα4n). The possible shift of the position of the maxima for reactions with emission of only neutrons by 2 — 3 Mev towards the side of higher energies, which is due to the angular momentum of the compound nucleus,[4] does not change the conclusions substantially. Considering the cross section for the production of Rn^{211} for 83-Mev nitrogen ions to be the upper limit for the cross section of the reaction (N, 4n), we can estimate the value of the ratio Γ_n/Γ_f for the isotopes $Th^{223-219}$, namely $\overline{\Gamma_n/\Gamma_f} < 0.8$.

The isotopes with half life ~ 150 days is obviously Po^{210} (T = 140 days, E = 3.53 Mev), which is produced by various reactions such as (N, xαn), (N, p4n), (N, N^{13}), and several others. The cross section for the production of Po^{210} increases with increasing energy, and reaches $\sim 10^{-25}$ cm^2 at E = 100 Mev.

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MAGNETIC MOMENTS AND CURIE POINTS OF FERRITES OF THE Cu-Cd *SYSTEM*

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We have studied the temperature dependence of the specific saturation magnetization σ_S and have determined the magnetic moments of solid-solution ferrites of the system $Cd_xCu_{1-x}Fe_2O_4$, in which the Cd^{+2} concentration was increased beyond 10% of the total number of bivalent ions. As far as we know, no one has previously carried out such studies of this system.

The specific magnetization σ was measured in the field interval 6000 to 13,000 oe, at six different values of temperature in the interval 78 to 293° K. The saturation magnetization at each temperature was determined by extrapolation to $H = \infty$ of the relation $\sigma = \sigma_S(1 - a/H)$. It was established that for the specimens rich in copper ions, and possessing the higher Curie points, the results of the measurements are best summarized by the formula $\sigma_S = \sigma_0(1 - \alpha T^{3/2})$. For the specimens rich in cadmium ions, with the lower Curie points, the relation $\sigma_S = \sigma_0(1 - \alpha T^2)$ holds. The absolute saturation magnetization σ_0 at each composition was determined by linear extrapolation to 0° K of the appropriate relation between σ_S and $T^{3/2}$ or T^2.

The curve in Fig. 1 shows the dependence of the magnetic moment, expressed in Bohr magnetons per "molecule" of the solid solution, on its composition. The dashed line shows the values of the magnetic moment calculated theoretically by assuming complete antiparallelism of the spins of the A and B sublattices. The deviations of the experimental data on the magnetic moment from the theo-