The $Mg^{24}(\gamma,3p3n)F^{18}$ Reaction Induced by 70-Mev Bremsstrahlung*

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F^{18} was identified among the products of an irradiation of Mg by 70-Mev bremsstrahlung by means of its chemical and radioactive properties. Considering the F^{18} to be formed solely by the loss of six nucleons from Mg^{24}, the yield of the process $Mg^{24}+\gamma\rightarrow F^{18}$ was 0.042 on the basis of unity for $N^{14}+\gamma\rightarrow N^{13}+n$. Preliminary experiments have indicated that 70-Mev bremsstrahlung gives the processes $Ca^{40}+\gamma\rightarrow Cl^{34}$ and $Cl^{35,37}+\gamma\rightarrow Si^{31}$.

MAGNESIUM metal has been irradiated by the 70-Mev bremsstrahlung beam of the Iowa State College synchrotron. After dissolving, the magnesium fraction was precipitated as a basic carbonate in the presence of sodium ion hold-back carrier to remove the 15.1-hr Na^{24} activity. Only one activity, half-life 110–115 min, was detected in the magnesium within the range of 10 min to 15 hr. This activity was concentrated in a fractional precipitation of MgF_2. Subsequently, its identity as the well-known 112-min F^{18} was established by its absorption characteristics and by a chemical procedure in which it followed fluoride carrier through a steam distillation as SiF_4, hydrolysis of the SiF_4, precipitation of a $Zn(OH)_2$ scavenger, and precipitation as PbClF.

To determine the relative yields for this process, a number of targets were irradiated by the 70-Mev bremsstrahlung. In each case the yield of two radioactivities prepared in the same target were compared. Corrections for air, window and cover absorption, sample self-absorption, and self-scattering were applied.[1–3] The experimental yield comparisons are in Table I. The ratios given are averages of 3 to 6 determinations. In Table II relative yields have been expressed on an isotopic basis and relative to the $N^{14}(\gamma,n)N^{13}$ yield following the convention of other workers[4–6] whose values are given for comparison.

TABLE I. Experimental relative yield determinations for 70-Mev bremsstrahlung.

Target	Reactions compared	Yield ratio per target atom
NH_4HF_2	$F^{19}(\gamma,n)F^{18}$—112 min / $N^{14}(\gamma,n)N^{13}$—10 min	2.8
MgF_2	$Mg(\gamma,—)Na^{24}$—15.1 hr / $F^{19}(\gamma,n)F^{18}$	0.19
Mg	$Mg(\gamma,—)F^{18}$ / $Mg(\gamma,—)Na^{24}$	0.062
Na_2CO_3	$Na^{23}(\gamma,2p3n)F^{18}$ / $C^{12}(\gamma,n)C^{11}$—20.5 min	0.092

The upper limit of possible fluoride content of the magnesium metal, which was not detected in a chemical analysis, precludes the possibility of the formation of F^{18} by a (γ,n) reaction of a fluoride impurity. Experiments are planned to determine the activation by this process as a function of the maximum photon energy. The formation of F^{18} by either a $(\gamma,\alpha d)$ process or by a $(\gamma,\alpha 2n)$ process followed by rapid beta decay has a threshold of 36–40 Mev for reasonable Coulomb barriers.

The slightly higher yield value for the $Na^{23}(\gamma,3p2n)F^{18}$ process than that obtained by Holtzman and Sugarman is to be expected for the higher irradiation energies. In these cases our yields have been in satisfactory agreement with those of Perlman and Friedlander rather than the considerably different values presented by Edwards and MacMillan.

Exploratory work has shown activation at 70 Mev for other elements involving the loss of a number of nucleons. An irradiation of Ca has yielded Cl^{33} which requires the loss of at least 6 nucleons. Si^{31}, formed by either $Cl^{35}(\gamma,3pn)$ or $Cl^{35}(\gamma,3p3n)$, has been found in irradiated LiCl.

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TABLE II. Relative yields of photonuclear processes for 70-Mev bremsstrahlung on the basis $N^{14}(\gamma,n)N^{13}=1$.

Reaction	This work	Relative yields
$F^{19}(\gamma,n)F^{18}$	2.8	2.8(50 Mev),[a] 10.9(70 Mev)[b]
$Mg^{25}(\gamma,p)Na^{24}$	5.3[c]	13.9 or greater (70 Mev)[b]
$Mg^{24}(\gamma,3p3n)F^{18}$	0.042[c]	
$Na^{23}(\gamma,2p3n)F^{18}$	0.22[d]	0.17(50 Mev)[d,e]

[a] See reference 4.
[b] See reference 5.
[c] Assuming all the activity to be formed by this reaction.
[d] Using the $C^{12}(\gamma,n)C^{11}$ value of Perlman and Friedlander (see reference 4).
[e] See reference 6.

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