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YIELDS OF MANGANESE IN SPALLATION REACTIONS

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YIELDS OF MANGANESE IN SPALLATION REACTIONS

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One approach previously used in the study of high energy spallation reactions involves the bombardment of a single target isotope and the determination of the relative yields of many products.[1] In the present work a complementary approach has been used: the bombardment of a variety of elements and the determination of the yields of two particular product isotopes. This method has the advantage that yields can be compared more exactly, since the same radiation is always measured. It also has the disadvantage that most of the target elements have several stable isotopes, so that the reacting nucleus cannot be uniquely specified. All of the elements (excepting only rubidium and krypton) from atomic number 24 (chromium) to 38 (strontium) were bombarded with 190-Mev deuterons in the 184-inch cyclotron. The yields of 5.8-day Mn^{52} and 2.59-hr. Mn^{56} were determined.

(1) B. B. Cunningham et al, Phys. Rev. 72, 739 (1947); H. H. Hopkins, Jr., and B. B. Cunningham, Phys. Rev. 73, 1406 (1948).

After each bombardment the target was dissolved and a known amount of inactive manganese was added, together with carriers for the other elements possibly produced. The manganese was separated chemically and the decay of its activity was followed. The chemical procedures used were varied depending on the target element, more complicated procedures being required for those far from manganese because of the low yields. The purest available materials (usually Hilger's "spectroscopically pure" grade) were used for targets.

In order to compare the yields from one bombardment with those from another, a monitor target was included in each experiment. A piece of 10 mil copper foil

cut to the exact shape and area of the target was placed immediately behind the target during exposure to the deuteron beam. Since all targets used were thin, it was assumed that each copper monitor foil received the same irradiation as the accompanying target. The yield of Cu^{64} in the monitor was taken to be a measure of the relative intensity of the deuteron beam.

The measured activities were corrected to infinite bombardment time and 100% chemical yield. In addition, the counting efficiency of Mn^{52} was assumed to be 40% relative to that of Mn^{56} and corrected accordingly. (Mn^{52} decays 35% by positron emission, 65% by K capture[2]; the 40% figure includes the contribution of

(2) W. M. Good, D. Peasloe, and M. Deutsch, Phys. Rev. 69, 313 (1946).

electromagnetic radiation to the counting rate.)

The data are presented in Fig. 1. The relative cross section, σ, is equal to the corrected manganese activity per mole of target element divided by the corrected Cu^{64} activity per mole of copper monitor. The uncertainty attached to each determination is indicated by the size of the plotted point.

It should be noted that the yield of the 21-minute isomer of Mn^{52} which decays[3]

(3) R. K. Osborne and M. Deutsch, Phys. Rev. 71, 467 (1947).

directly to Cr^{52} has not been included. The total yields of Mn^{52} are therefore somewhat higher than the data indicate.

The absolute cross section corresponding to $\sigma = 1$ is approximately 0.03 barn, according to a recent direct determination[4] of the cross section for Cu^{64}.

(4) R. Batzel, private communication.

It is of interest that the fluctuations by which the data deviate from smooth curves can be correlated with the distribution of stable isotopes present in the

natural elements used as targets, together with the variations in excitation energy required for reaction of the different isotopes. The excitation energies were estimated with the assumption that alpha-particles are favored over other charged particles in their evaporation from excited nuclei, and the agreement obtained affords some support for this hypothesis.

The cooperation of the 184-inch cyclotron crew in performing the bombardments is gratefully acknowledged. This work was performed under the auspices of the United States Atomic Energy Commission.

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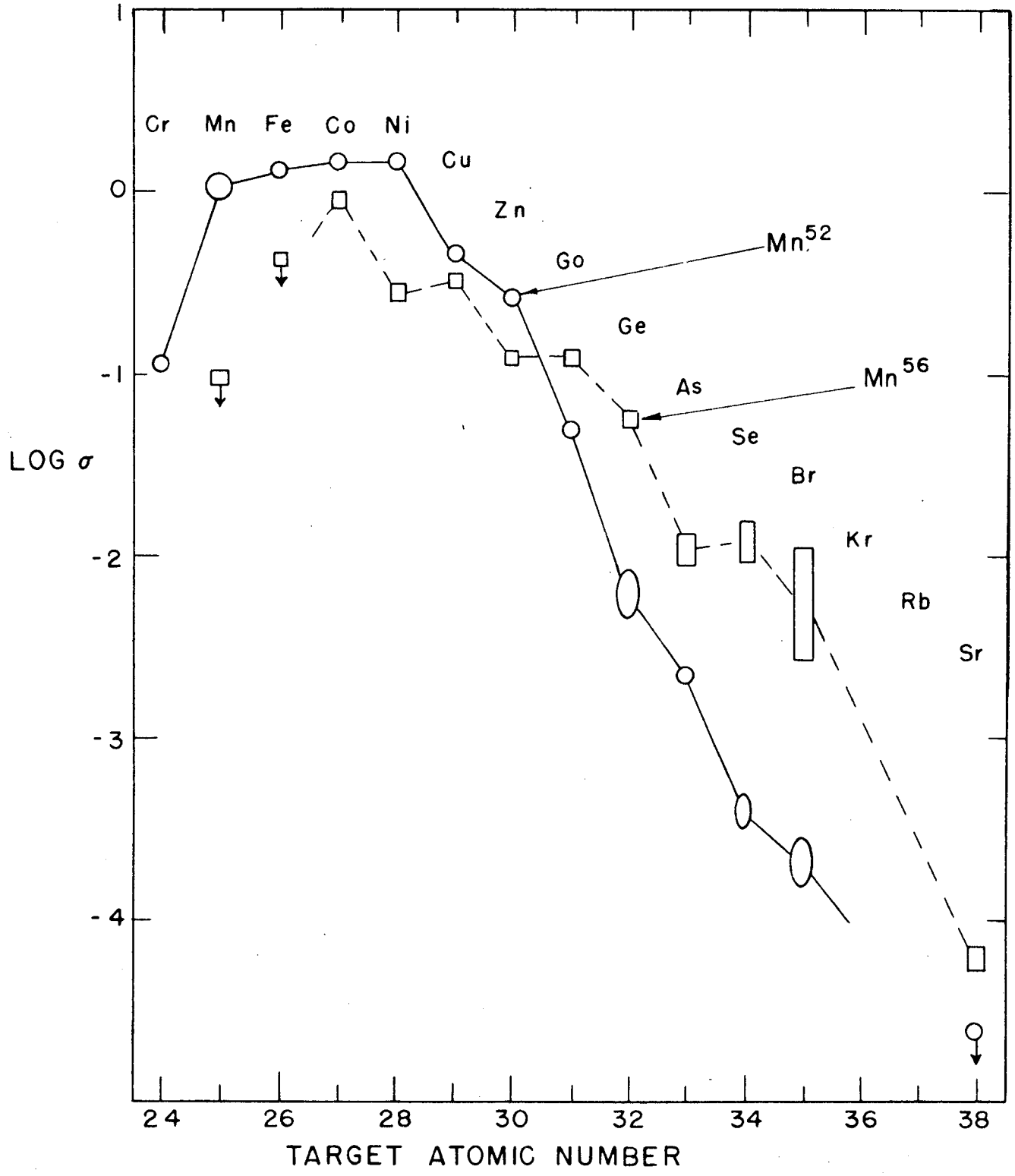
Legend for Figure 1: Relative cross sections for the production of two manganese isotopes by bombardment of various elements with 190-Mev deuterons. Points with arrows attached represent upper limits.


Cr
Mn
Fe
Co
Ni
Cu
Zn
Go
Ge
As
Se
Br
Kr
Rb
Sr
Mn^{52}
Mn^{56}
LOG σ
1
0
-1
-2
-3
-4
24
26
28
30
32
34
36
38
TARGET ATOMIC NUMBER