SHORT COMMUNICATIONS

CROSS SECTIONS FOR THE INTERACTION OF 14·5 MeV NEUTRONS WITH MANGANESE AND COBALT*

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Cross sections for (n,p), $(n,2n)$, and (n,α) reactions have been extensively investigated for neutron energies near 14 MeV. However, there are still some gaps, and the present investigations were undertaken to provide neutron cross-section data for nuclei near the proton number 28. Although manganese and cobalt are both monoisotopic elements and, therefore, relatively simple to study by activation techniques, very few measurements have, in fact, been reported.

The target samples in these experiments were in the form of thin circular disks of diameter 0·5 in. sandwiched between a pair of similar copper disks. The sandwiches were irradiated for known periods, shorter than the half-life of the activity to be measured, in a steady flux of $(14\cdot5\pm0\cdot5)$ MeV neutrons produced by the $^{3}H(d,n)^{4}He$ reaction.

After irradiation the activated samples were removed to a heavily shielded scintillation spectrometer employing a 2 in. high by $1\frac{3}{4}$ in. diameter NaI(Tl) crystal, where γ-ray counting was carried out in constant geometry. For ease of calibration of the system only counts in the photo-peak were used. Photo-peak efficiencies, relative to the efficiency for annihilation quanta, were measured experimentally using ^{58}Co and ^{22}Na to give calibration points close to the energies of the detected γ-rays. The flux at the manganese or cobalt foil was taken to be the mean of the front and back copper monitor foils, whose activities were determined by counting the annihilation quanta emanating from 9·9 min ^{62}Cu. The radioactive isotopes produced were identified by their radiations and half lives.

The cross sections obtained are relative to a value of (522 ± 20) mbarn for the $^{63}Cu(n,2n)^{62}Cu$ reaction (the weighted mean of several published values : Forbes 1952 ; Paul and Clarke 1953 ; and Yasumi 1957) or, in the case of the longer lived activities, relative to a measured value of (1030 ± 95) mbarn for the reaction $^{65}Cu(n,2n)^{64}Cu$.

Five or more independent measurements were made for each cross section determined, and the results given below represent the weighted mean of these measurements.

Reaction $^{65}Cu(n,2n)^{64}Cu$

Foils of natural copper were irradiated and the annihilation quanta from 12·87 hr ^{64}Cu were detected and counted after the 9·9 min ^{62}Cu monitoring activity had decayed. Positrons are emitted in 19 per cent. of the ^{64}Cu

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disintegrations (Strominger, Hollander, and Seaborg 1958). The cross section relative to the ^{63}Cu(n,2n)^{62}Cu cross section of (522 ± 20) mbarn was found to be (1030 ± 95) mbarn.

This may be compared with the values of (964 ± 78) mbarn reported by Rayburn (1959) relative to a ^{63}Cu(n,2n)^{62}Cu cross section of 500 mbarn, (954 ± 130) mbarn by Paularikas and Fink (1959) relative to a ^{63}Cu(n,2n) cross section of 556 mbarn, and (1087 ± 170) mbarn by Paul and Clarke (1953), who find the ^{63}Cu cross section to be (482 ± 70) mbarn.

Reaction ^{55}*Mn*(n,2n)^{54}*Mn*

The reaction cross section was obtained by counting the 0·84 MeV γ-rays emitted by 291 day ^{54}Mn, and is (825 ± 185) mbarn.

Reaction ^{55}*Mn*(n,α)^{52}*V*

By detecting the 1·43 MeV γ-rays following the β-decay of 3·76 min ^{52}V, the cross section was found to be (27 ± 5) mbarn.

Paul and Clarke (1953) measured a 3·9 min β-activity and attributed the resulting cross section of (52 ± 8) mbarn to the (n,α) reaction. However, the (n,p) reaction leads to 3·6 min ^{55}Cr, a pure β-emitter with end point energy of 2·85 MeV compared to 2·5 MeV for ^{52}V. Paul and Clarke identified their β-activities from half-lives given in the National Bureau of Standards Circular 499 (1952); the 3·6 min ^{55}Cr has been reported subsequently. Their observed β-activity therefore should be due to both the (n,p) and (n,α) reactions. Thus subtraction indicates a value of approximately 25 mbarn for the (n,p) reaction.

Reaction ^{59}*Co*(n,2n)^{58}*Co*

Radioactive ^{58}Co is formed both in the 71 day ground state and a 9 hr isomeric state which decays to the ground state. The ground state decays to ^{58}Fe by electron capture or positron emission, followed by a 0·80 MeV γ-ray in 99·5 per cent. of the disintegrations (Strominger, Hollander, and Seaborg 1958). The ^{59}Co(n,α) reaction leads to 2·58 hr ^{56}Mn, whose decay scheme includes a 0·84 MeV γ-ray. By following the 0·8 MeV activity until all the ^{56}Mn and the 9 hr ^{58}Co isomer had decayed, it was found that (45 ± 25) per cent. of the ^{59}Co(n,2n) reactions went through the 9 hr isomeric state.

Measurements of the (n,2n) cross section were made by detecting and counting the 0·80 MeV γ-activity after the decay of the 9 hr isomer. The weighted mean of five independent measurements gives the value of (855 ± 165) mbarn for this cross section.

Reaction ^{59}*Co*(n,p)^{59}*Fe*

Heath, Proctor, and Reich (1959) reported that 55·6 per cent. of the disintegrations of 45 day ^{59}Fe were followed by a 1·10 MeV γ-ray, and 44·1 per cent. by a 1·29 MeV γ-ray. Measurement of these γ-ray activities gives an (n,p) cross section of (80 ± 23) mbarn.

Reaction ^{59}*Co*(n,α)^{56}*Mn*

The γ-ray activity was corrected for the presence of the 0·8 MeV γ-rays from the (n,2n) reaction. The resulting (n,α) cross section was found to be

(29 ± 6) mbarn relative to the ^{65}Cu$(n,2n)$ cross section. This is in good agreement with the value of (31 ± 3) mbarn relative to a ^{56}Fe(n,p) cross section of 110 mbarn reported by Blosser, Goodman, and Handley (1958).

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