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LOS ALAMOS SCIENTIFIC LABORATORY

of

THE UNIVERSITY OF CALIFORNIA

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TOTAL CROSS SECTIONS FOR 14-MEV NEUTRONS

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PHYSICS AND MATHEMATICS

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Total cross sections of carbon, polyethylene, water, heavy water, formic acid, nitrogen and copper for 14.2-Mev neutrons were obtained from "good geometry" transmission experiments. Neutrons were produced by the $T(D,n)He^4$ reaction on a Cockcroft-Walton accelerator operated at 250 kilovolts. The analyzed diatomic deuteron beam was used to bombard a thick zirconium-tritium target[1]. If the reaction energy is taken as 17.60 Mev, the neutron energies ranged from 14.08 to 14.35 Mev at the angle (70° to the beam) at which the measurements were made. The effective target area, and hence the neutron source size, was limited to a circle about 1/4 inch in diameter.

Copper strips 3/8 inch x 12 inch x 0.003 inch, wrapped in tight spirals, were used to detect the neutrons by the $Cu^{63}(n,2n)Cu^{62}$ reaction[2]. The strip was wound in a helix around a Geiger tube for counting. Scattering samples and the detector spirals were suspended from a taut music wire and aligned with a transit. The scatterers were located midway between the source and the detector. A detector spiral and a monitor spiral were 90 cm from the source and were 90 cm apart.

Background activity due to room-scattered neutrons was determined by placing a 25-inch long copper bar between source and detector. A simple calculation shows the transmission of neutrons through

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1. Graves, Rodrigues, Goldblatt & Meyer, Rev. Sci. Inst. 20, 579 (1949).
2. J. L. Fowler and J. M. Slye, Phys. Rev. 77, 787, (1950).

such a bar is negligibly small. The measured activity of the bare detector was 3% of the activity without the bar and had a five minute half-life. This is characteristic of the reaction $Cu^{65}(n,\gamma)Cu^{64}$ which is excited chiefly by slow neutrons. Shielding the detector with cadmium reduced this background to 0.3%.

All scattering samples except copper were 1 inch in diameter. The copper samples were 1/2 inch and 1 inch in diameter. This corresponds to maximum angles for scattering of neutrons into the detector of 1.70° and 3.50° for the 1/2 inch and 1 inch samples, respectively. In general the length of the scattering sample was such as to give a transmission of approximately 0.5. The transmission is defined as the ratio of the neutron flux as measured by the detector with a scattering sample in the path of the neutrons to the neutron flux with no scattering sample in the path of the neutrons.

Effects of small-angle scattering and multiple scattering were found to be negligible for copper, which is the case for which such effects would be greatest. No difference in cross section was observed with copper scatterers of 1 inch and 1/2 inch diameters, within the limit of error of the measurement. The statistical errors in each case were 0.8%. Furthermore, no multiple scattering effect was observed when copper samples with transmissions of 0.50 and 0.26 were compared. The statistical errors here were also 0.8%. The magnitude of the error in the cross section due to elastic scattering of neutrons into the detector by the scatterer can be estimated by the method of McMillan and Sewell[3]. This error would be 1% for the measurement using the 1 inch diameter copper scatterer and 1/4% for the measurement using the 1/2 inch diameter copper scatterer. In all other cases this correction was less than 1/2%. No correction for this effect was applied to any of the measurements.

In all measurements except those with nitrogen, the largest known error was the statistical error in counting. The standard deviation of the observed transmissions was 0.6%. An error of this magnitude in the transmission would cause an error of 1.2% in the cross section. The cross sections for hydrogen, deuterium, and oxygen were determined from differences and hence have larger errors. Liquid nitrogen was used for the nitrogen measurement and in this case the determination of the density was the largest error.

The formic acid and polyethylene samples were chemically analyzed by A. R. Ronzio, of Group H-4, who found that the chemical formulas and masses of these samples were correct to within a few tenths of a percent. The purity of the other samples is not known, but is believed to be high.

Cross sections were evaluated by the relation $\sigma = \frac{1}{nx} \log \frac{1}{T}$, where n is the number of atoms or molecules per cm^3, x is the length of

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3. Edwin M. McMillan & Duane C. Sewell, U.S.AEC publication MDD5-1558.

the scattering sample in centimeters, and T is the transmission corrected for the effect of room-scattered neutrons. Results are listed in the table below.

TOTAL NEUTRON CROSS SECTIONS AT 14.2 MEV

SCATTERER	MOLECULAR CROSS SECTION (barns)	ELEMENT	ELEMENT CROSS SECTION (barns)	SCATTERERS USED FOR DETERMINATION OF ELEMENT CROSS SECTION
C		C	$1.29 \pm .02$	C
CH_2	$2.64 \pm .03$	H	$0.675 \pm .020$	CH_2,C
H_2O	$2.97 \pm .03$	O	$1.62 \pm .04$	H_2O,CH_2,C
CH_2O_2	$5.84 \pm .10$	O	$1.60 \pm .04$	CH_2O_2, CH_2
D_2O	$3.23 \pm .03$	D	$0.81 \pm .03$	D_2O,H_2O,CH_2,C
N		N	$1.39 \pm .05$	N
Cu		Cu	$2.85 \pm .05$	Cu

Total cross section measurements in the same energy region have been reported by Ageno, et al[4] and Lasday[5].

4. Ageno, et al, Phys. Rev. 71, 20, (1947)

5. Albert H. Lasday, Phys. Rev. 81, 139 (1951)