A Study of the Protons from V, Cu, Mn, and Sc under Bombardment by Deuterons

Absorption studies have been carried out on the protons from the following reactions.

1. $V^{51}+H^2\rightarrow V^{52}+H^1$,
2. Cu^{63}, $Cu^{65}+H^2\rightarrow Cu^{64}$, $Cu^{66}+H^1$,
3. $Mn^{55}+H^2\rightarrow Mn^{56}+H^1$,
4. $Sc^{45}+H^2\rightarrow Sc^{46}+H^1$.

Deuterons of 3.1-Mev energy, accelerated in a cyclotron, were utilized and the average current was 2 microamperes. The protons were detected by a proportional counter operating into a conventional amplifier, the output pulses being fed to a scale-of-10 recording circuit.[1]

Table I gives the ranges of the groups found as well as the resulting "Q" values. Possible groups with ranges less than that of $C(dp)$ protons (34 cm) have been left for further study, since carbon from the oil diffusion pumps is inevitably present on all targets. Assignments of the groups to the reactions responsible are unique except for Cu, since the other targets represent 100 percent isotopes. In the case of Cu assignment is made of the 87.5-cm group to the reaction

$$Cu^{63}+H^2\rightarrow Cu^{64}+H^1,$$

corresponding to the formation of the ground state of Cu^{64}; and the 99.5-cm group to

$$Cu^{65}+H^2\rightarrow Cu^{66}+H^1,$$

resulting in the ground state of Cu^{66}. One is led to such an assignment since the former group has double the intensity of the latter group, in keeping with the abundance ratio of the two Cu isotopes. As a check on this the corresponding "Q" values have been used along with Dempster's[2] mean packing fraction for Cu^{63}, Cu^{65} to deduce the masses of Cu^{64} and Cu^{66}. The values obtained are in good agreement with those found from Dempster's[2] packing fractions for Zn^{64} and Zn^{66} together with the maximum β-ray energies from Cu^{64} and Cu^{66} found by Sinma and Yamasaki.[3] However, the magnitude of the probable errors in these latter values is such that the agreement cannot be taken as conclusive proof of the assignment but only as an indication of its correctness. Until the γ-rays given off by Cu under bombardment by deuterons are investigated, it will be impossible properly to assign the 52.5-cm and 66.5-cm groups present.

Table II lists the excitation levels found for the various nuclei; also the masses deduced from the largest energy release found in each reaction. The mass of V^{52} was determined using that of V^{51} as obtained by Davidson and Pollard[4] from the reaction

$$Ti^{48}+He^4\rightarrow V^{51}+H^1.$$

This in turn involved Dempster's[2] value for the mass of Ti^{48}.

The mass of Mn^{55} was arrived at from Dempster's[2] packing fraction for Fe^{56} and Brown and Mitchell's[5] value for the energy limit of the β-rays from Mn^{56}.

In the case of Sc^{46} the mass was determined with the aid of Pollard's[6] mass value of Sc^{45} which he deduced from the reaction

$$Sc^{45}+He^4\rightarrow Ti^{48}+H^1,$$

again with the assistance of Dempster's mass for Ti^{48}. The probable error in the (αp) reactions used above was estimated at the relatively large value of ± 0.0005 mass units since natural sources of alpha-particles were employed. It is felt that the much greater yields obtained in the (dp) reactions here reported together with better geometry merit a probable error conservatively placed at ± 0.0003 mass units. The errors in the packing fractions used are those given by the author.

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WILLIAM L. DAVIDSON, JR.
Sloane Physics Laboratory,
Yale University,
New Haven, Connecticut,
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TABLE I. *Ranges and "Q" values for the reactions studied.*

Residual Nucleus	Range of Proton Groups (cm air equiv.)			"Q" Values (Mev)		
1. V^{52}	46	80	127.5	+3.10	+5.33	+7.80
2. Cu^{64} / Cu^{66}	52.5	66.5	87.5 / 99.5	+3.54	+4.35	+5.70 / +6.35
3. Mn^{56}	50.5	69	103	+3.40	+4.62	+6.57
4. Sc^{46}	65.5	104.5			+4.48	+6.78

TABLE II. *Excitation levels and calculated masses of several nuclei.*

Nucleus	Excitation Levels (Mev)		Deduced Masses
V^{52}	2.47	4.70	51.9580±.0013
Cu^{64}			63.9572±.0016
Cu^{66}			65.9551±.0016
Mn^{56}	1.95	3.17	
Mn^{55}			54.9643±.0025
Sc^{46}	2.30		45.9682±.0013

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[6] Ernest Pollard, Phys. Rev. **54**, 411 (1938).

The Secondary Emission from Evaporated Nickel and Cobalt

In a recent paper[1] the author has derived an equation which connects the shape of the secondary yield (δ) *versus* primary energy (E_p) curve for a metal with certain of the physical constants of the target material. Since the development assumed complete randomness in the orientations of the crystallites of the target, this equation is best tested against the results of measurements on evaporated metals. The purpose of this note is to present δ *vs.* E_p data for evaporated nickel and cobalt, and to compare with the theoretical predictions.

The measurements were made in a simple tube, constructed so that all the elements could be outgassed by electron bombardment. The geometry of the tube had been carefully designed so as to contribute only very small errors to the absolute magnitudes of the quantities meas-