the pairs are somewhat less intense with respect to the gamma-rays than would be expected, by perhaps a factor of three. This may be due to experimental difficulties of calibration, or possibly to enhanced competition of two quantum emission with pair emission from the oxygen pair level produced by one or more fairly low lying 1^- levels of oxygen.[6] 4. In general, many fewer long range alpha-particles are observed than expected. This again may be due to calibration errors, or it may indicate an overestimate of the partial breadth for emission of long range alpha-particles. 5. The 832- and 1362-kev pair resonances should be accompanied by gamma-rays, since with the assignments given in Table II the 1^+ oxygen level can also be reached by alpha-particle emission in these cases. These would, however, be masked by the strong 862- and 1363-kev gamma-ray resonances, respectively. 6. A careful search should be made for the weaker long range alpha-particles that are expected to accompany the 1100- and 1220-kev pair resonances. 7. Measurement of the angular distribution of the long range alpha-particles at their resonances would provide an independent check on the assignments of those levels.

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Experimental Yields with 14-Mev Deuterons*

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Thick target yields for the production of seventeen radioactive isotopes by deuteron bombardment are reported in terms of absolute disintegrations per second per microampere hour of 14-Mev deuterons.

TABLE I presents thick target yields obtained by bombarding various targets with the 14-Mev deuteron beam of the M.I.T. cyclotron. The deuteron energy was determined by range measurements in aluminum.[1] Yield data are given as absolute disintegration rates, in terms of 10^6 disintegrating atoms per second per microampere hour of deuterons. As recommended by the National Bureau of Standards and the National Research Council Committee on Standards of Radioactivity,[2] a disintegration rate of 10^6 disintegrations per second is called 1 rutherford (rd); if the millicurie (mC) is arbitrarily taken as 37×10^6 disintegrations per second, then 1 mC = 37 rd, or 1 rd = 0.027 mC = 27 μC. Absolute disintegration rates of gamma-ray emitters were determined on a calibrated gamma-ray counter,[3] while those of isotopes decaying only by beta-ray emission were found on a thin-window beta-ray counter[4] whose absolute efficiency was known.

The first four columns of the table list the characteristics of the processes: the isotope and its half-life,[5] its type of radiation, the target isotope, and the deuteron reaction producing it. The disintegration schemes upon which yield measurements were based are published in the references given in column V. Column VI gives the lower deuteron energy limit below which the reaction cannot be produced. Column VII contains the observed thick target yields which

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TABLE I. Data on thick target yields.

I Isotope	II Half-life	III Radiation	IV Reaction	V Disint. scheme	VI Threshold Mev	VII Yield* rd/μah	VIII Practical target	IX Method of measurement
$_{11}Na^{22}$	3.0 yr.	β^+, γ	$Mg^{24}(d, \alpha)$	a	—	0.065	Mg=1	Ex. fn
$_{11}Na^{24}$	14.8 hr.	β^-, γ	$Na^{23}(d, p)$	b	—	410	Na=1	Ex. fn
$_{11}Na^{24}$	14.8 hr.	β^-, γ	$Mg^{26}(d, \alpha)$	b	—	8.70	Mg=1	Ex. fn
$_{11}Na^{24}$	14.8 hr.	β^-, γ	$Al^{27}(d; p, \alpha)$	b	10	1.66	Al=1	Ex. fn
$_{14}Si^{31}$	170. min.	β^-	$Si^{30}(d, p)$	c, d	—	37	SiO_2=0.47	Thick target
$_{15}P^{32}$	14.30 day	β^-	$P^{31}(d, p)$	c, e	—	8.5	P=1	Thick target
$_{17}Cl^{38}$	37. min.	β^-, γ	$Cl^{37}(d, p)$	f	—	1500	$CaCl_2$=0.64	Thick target
$_{19}K^{42}$	12.4 hr.	β^-	$K^{41}(d, p)$	c	—	8.3	K=1	Thick target
$_{25}Mn^{52}$	6.5 day	β^+, K, γ	$Cr^{52}(d, 2n)$	g	8	3	Cr=1	Thick target
$_{27}Co^{60}$	5.3 yr.	β^-, γ	$Co^{59}(d, p)$	h	—	0.040	Co=1	Ex. fn
$_{29}Cu^{64}$	12.8 hr.	β^-, β^+, K	$Cu^{63}(d, p)$	i	—	92	Cu=1	Ex. fn
$_{30}Zn^{63}$	38. min.	β^+	$Cu^{63}(d, 2n)$	j	6.5	1160	Cu=1	Ex. fn
$_{30}Zn^{65}$	250. day	K, γ	$Cu^{65}(d, 2n)$	k	4.6	0.126	Cu=1	Ex. fn
$_{35}Br^{82}$	34 hr.	β^-, γ	$Br^{81}(d, p)$	l	—	28.5	NaBr=0.80	Ex. fn
$_{36}Kr$	34 hr.	β^+, γ	$Br(d, 2n)$	—	5	190μg Ra	NaBr=0.80	Ex. fn
$_{38}Sr^{89}$	55 day	β^-	$Sr^{88}(d, p)$	m, n	—	1.3	$SrCO_3$=0.60	Thick target
$_{39}Y^{88}$	87 day	K, γ	$Sr^{88}(d, 2n)$	o	6	1.4	$SrCO_3$=0.60	Thick target
$_{53}I^{130}$	12.6 hr.	β^-, γ	$Te^{130}(d, 2n)$	p	?	32	Te=1	Thick target
$_{53}I^{131}$	8.0 day	β^-, γ	$Te^{130}(d, n)$	q	—	3.2	Te=1	Thick target

* 1 rd = 10^6 disintegrating atoms per second.
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[p] See reference 3 in text.
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would be obtained by bombardment of the pure element (natural isotopic mixture) given in column IV. Column VIII gives the target material generally used, together with the factor by which the given yield must be multiplied to obtain the practical yield.

The last column describes the method of measurement of the particular yield. Those obtained from excitation functions[1] are more accurate (probable error 10 percent) than those found by bombarding thick samples (probable error 20 percent) because the deuteron energy here could not be evaluated with as much certainty. This is particularly true of Mn^{52}, where the yield at 14 Mev is a rapidly varying function of energy.

Since the disintegration scheme for Kr is not known, the yield is given in micrograms radium gamma-ray equivalent, measured on a platinum screen wall gamma-ray counter shielded by 0.16-cm lead.