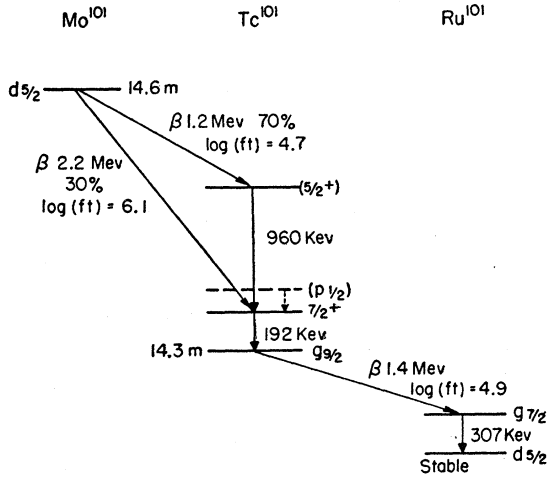

FIG. 1. Proposed decay scheme for Mo^{101} and Tc^{101}.

to the 7/2 state, which in turn decays by an $M1$ transition to the ground state.

Rutledge, Cork, and Burson proposed a decay scheme for Mo^{101} and Tc^{101} which is consistent with all present evidence. No reasonable alternate could be found that is consistent with the data of Table I and the absence of evidence for the $p_{\frac{1}{2}}$ isomer. The highest observed level in Tc^{101} appears to be the 5/2+ compound level. The only other reasonable possibility is a 3/2+ state, which would decay by a fast transition to the $p_{\frac{1}{2}}$ level. The results of coincidence measurements of Rutledge *et al.*[2] eliminate this possibility. The $d_{5/2}$ level of the next higher shell would be consistent with all observed lifetimes, would not be expected at an excitation of less than about 3 Mev. This scheme is given as Fig. 1, with the addition of spin assignments made on the basis of *ft* values, γ transition probabilities, and predictions of the nuclear shell model.

A value of 1.3 was found for the ratio of (d,p) cross sections of Mo^{100} and Mo^{98}.

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Average Charge of Recoil Atoms from Several Nuclear Transitions*

S. WEXLER
Argonne National Laboratory, Lemont, Illinois

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The average charge of daughter atoms following nuclear transformation has been measured for several active species. The positive ion current of the decay products was observed in the gas of the parent at low pressure and compared with the disintegration rate of the active nuclide. The average charges found in the several transitions studied appear in the following table:

Parent activity	Type of nuclear decay	Av. positive charge (electron units)
T_2	β^-	0.9±0.1
$C^{14}O_2$	β^-	1.0±0.2
A^{41}	β^-	1.0±0.1
Mixture of fission gases (Kr^{83m}, Kr^{85}, Kr^{87}, Kr^{88}, Xe^{135})	β^-, γ, I.T. (γ, e^-)	~1.3
$C_2H_5Br^{80m}$	Isomeric transition (γ, e^-)	10±2
Kr^{83m}	Isomeric transition (γ, e^-)	7.7±0.4
A^{37}	Electron capture	3.0±0.2

A. INTRODUCTION

POSITIVE charges have been observed on large fractions of the recoils from radiative capture,[1,2] isomeric transition by internal conversion,[3] β-decay,[1,4,5] and orbital electron capture.[6,7] Indeed, high positive charges are predicted for the products of isomeric transition by internal conversion.[8,9] The increase in nuclear charge in negative beta emission should give rise to at least a singly-charged ion of positive sign. The extent to which change in nuclear charge should induce orbital electron ionization in beta decay has been discussed by several authors.[10–14]

* A preliminary report on this study appeared in Phys. Rev. **88**, 1203 (1952).
[1] S. Wexler and T. H. Davies, J. Chem. Phys. **20**, 1688 (1952).
[2] S. Yosim and T. H. Davies, J. Phys. Chem. **56**, 599 (1952).
[3] S. Wexler and T. H. Davies, J. Chem. Phys. **18**, 376 (1950).
[4] J. C. Jacobsen and O. Kofoed-Hansen, Phys. Rev. **73**, 675 (1948).
[5] Allen, Paneth, and Morrish, Phys. Rev. **75**, 570 (1949).
[6] G. W. Rodeback and J. S. Allen, Phys. Rev. **86**, 446 (1952).
[7] P. B. Smith and J. S. Allen, Phys. Rev. **81**, 381 (1951).
[8] D. C. DeVault and W. F. Libby, J. Am. Chem. Soc. **63**, 3216 (1941).
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[10] A. Migdal, J. Phys. (U.S.S.R.) **4**, 449 (1941).
[11] E. L. Feinberg, J. Phys. (U.S.S.R.) **4**, 423 (1941).
[12] A. Winther, Kgl. Danske Videnskab. Selskab. Mat.-fys. Medd. **27**, No. 2 (1952).
[13] H. Schwartz, J. Chem. Phys. **21**, 45 (1953).
[14] J. S. Levinger, Phys. Rev. **90**, 11 (1953).

Very recently, the average charge following transition by internal conversion of Xe^{131m} and that of Cl^{37} from the similar process of electron capture by A^{37} have been reported.[15] The charge carried by the products of β^- decay has been measured only for the single case of Kr^{88}.[4] Early papers deal with similar studies on recoils from α emission.[16,17] More recently, very high charges have been found on fission fragments.[18] This paper describes an experiment to determine the average charge carried by daughter atoms after beta decay of molecular tritium, $C^{14}O_2$, A^{41}, and of a mixture of Kr and Xe fission gases. Results on the products from isomeric transition of 4.4-hr Br^{80m}, as tagged ethyl bromide, and of 113-min Kr^{83m} will also be presented. In addition, a measurement in our apparatus of the average charge produced by electron capture of A^{37} will be described. The experiment measures the positive ion current of the charged daughter atoms in gases of the parent at very low pressure. The number of electron units of charge collected by a probe in unit time is compared with the disintegration rate of the parent to give the average charge per disintegration.

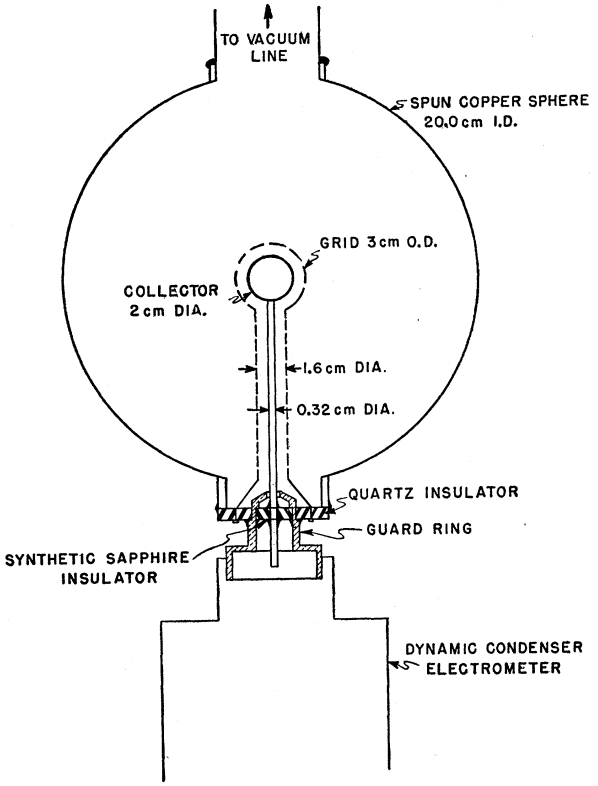

FIG. 1. Spherical ion collection chamber.

[15] M. S. Perlman and J. A. Miskel, Phys. Rev. **91**, 899 (1953). This article appeared after the present paper was submitted for publication.
[16] J. D. McGee, Phil. Mag. [7], **13**, 1 (1932).
[17] Mond, Capron, and Jadogne, Bull. soc. chim. Belges No. 1 (1931).
[18] N. O. Lassen, Phys. Rev. **68**, 142 (1945).

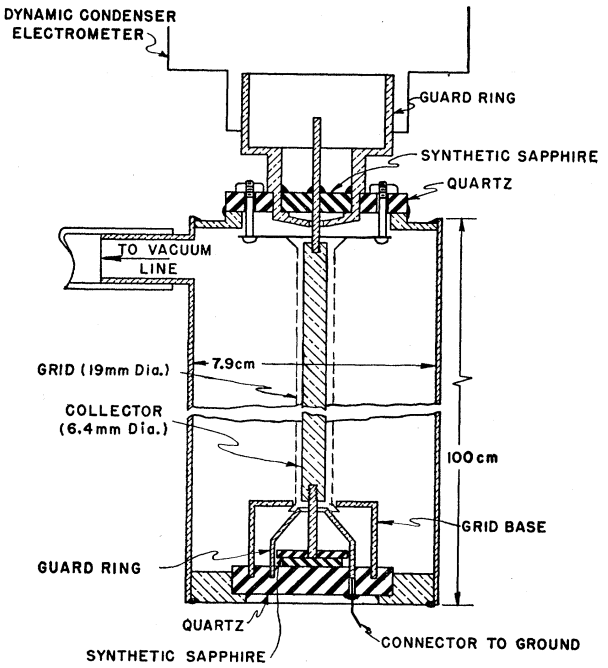

FIG. 2. Cylindrical ion collection chamber.

B. PROCEDURES

1. Ion Current Measurement

In Figs. 1 and 2 are schematically drawn the copper sphere and cylinder, respectively, into which the active gases were introduced in order to measure the positive ion currents of the recoils. A battery-supplied potential at the chamber shell drove to the collector the positive ions formed in the gas volume. The grid surrounding the probe was held at a small negative voltage relative to the latter and sufficient to suppress secondary electrons formed at the surface of the collector. The open portion of the grid structure was either 65 or 88 percent of the total area. The gas space between grid and chamber wall, from within which the positive decay products are collected, was calculated from the dimensions to be 4105 and 4460 cc in the sphere and cylinder, respectively. The "dead" space between grid and collector was five percent of the total cylindrical volume and a much lower fraction of the sphere. Ion currents to the probe were measured in an attached dynamic condenser electrometer and recorded as voltages across calibrated resistances. In many observations the rate-of-drift method was employed with a known electrometer capacitance. Ion currents measured by the two procedures agreed within five percent. The electrometer was calibrated by means of known voltages from a potentiometer.

In order that the electrometer readings be significant, it is clearly necessary that the ion currents collected be composed of all positive ions formed from nuclear decay, with no addition of other positive ions. Some evidence that this was the case came from preliminary

tests of the following type. For each active gas the proper electric field conditions were selected to drive all positive recoils formed between grid and shell to the collector and to suppress all secondaries at the surface of the probe. By alternately varying the grid and chamber voltages, it was found that saturation ion currents were usually obtained at shell potentials of 1000–1500 v. Grid voltages of −90 v usually sufficed to suppress all secondaries.

Ion currents measured in the primary experiments were corrected for that part intercepted by the grid structure. The portion of ion current reaching the collector was taken as equal to the fractional open area of the grid. Evidence that this procedure is correct comes from the similar results obtained from runs using grids of widely different transmissions (see below). Further, electric-field conditions analogous to those used here have been studied in electron optics. Within small error, the fraction of current intercepted by the grid in a cylindrical geometry is given by the fractional projected area of the grid.[19] Corrections to the electrometer readings were also made for chance interception of fast electrons by the collector and for the small background currents observed with the chamber evacuated.

Gas pressures of 5×10^{-5} to 5×10^{-3} mm, depending on the active nuclide, were present in the chamber at the time of the current measurement. In this range the ion current was proportional to the pressure of the active gas, suggesting that under these conditions positive ions produced by secondary effects, such as ionizing collisions of β^- particles, electrons, and recoils with the bulk gas, were not measurable. This observation appears to be supported by the very small cross sections reported for ionizing collisions.[20] It is estimated that at the pressures used recoils and electrons have mean free paths between ionizing collisions with gas molecules from 10 to 1000 times longer than the electrode separations.

The time necessary for decrease of the electrometer current to half its original value was compared, when feasible, to the half-life of the active species in the chamber. Good agreement was obtained for every gas studied. The current from 110-min A^{41} decay decreased to half-value in times of 100 to 115 minutes. For the mixture of fission gases, the electrometer period was 2.5 to 2.8 hr as compared with the average of 3.0 hr calculated. With 4.4-hr $C_2H_5Br^{80m}$, the times ranged from four to five hours in several determinations. On the other hand, the period was approximately 110 minutes when 113-min Kr^{83m} was present in the chamber. When one of the long-lived nuclides, 12.4-yr T_2, 5570-yr $C^{14}O_2$, or 35-day A^{37}, was introduced, the electrometer reading remained unchanged after several hours of observation. In contrast to the currents measured when the active species were in the chamber, only the small background currents found with the shell evacuated were observed when like but inert gases were introduced. Two further tests showed no detectable contribution to the primary ion current by charged decay products from beta active daughters of the fission gases, or by the 18-min daughter of Br^{80m}. In one, a rise of the electrometer current with time in the first hour after introducing the pure active gas into the chamber was looked for without success. This effect would have been due to growing in of the daughter activity if the latter were contributing to the current from the primary disintegration. In a second test, the electrometer reading was followed immediately on removal of the sample of active gas from the chamber. The current decreased in a few minutes to the background found with the chamber evacuated. If the activities of the nonvolatile decay products affected the positive ion current significantly, the electrometer, after an initial drop, should have decreased to half-value in times corresponding to the half-lives of the active daughters.

All the tritium and several of the fission-gas and $C_2H_5Br^{80m}$ measurements were made in the spherical assembly. The cylinder was used in the other studies reported on.

2. Disintegration Rate Measurement

The activity of the gas present in the chamber at the time of the current measurement was determined in a second experiment. A known aliquot of the active species, equal in pressure to that in the chamber, was submitted to a disintegration rate assay, the procedure depending on the radionuclide. Decay rates of tritium and $C^{14}O_2$ samples were determined in a calibrated ionization chamber of the type described by Borkowski.[21] The activity of the fission-gas mixture was obtained from the decay rate of the 18-min Rb^{88} daughter of 2.8-hr Kr^{88} in the following manner: An aliquot of the active mixture was allowed to decay in an evacuated copper cylinder for one hour, after which the gas was pumped out and the Rb^{88} entirely removed from the cylinder walls with dilute HNO_3 containing a small amount of rubidium carrier. After chemical purification, Rb_2PtCl_6 was precipitated and the 18-min activity measured under an end-window counter of known geometry. Correction was made for absorption and scattering of the betas and for chemical yield. From this decay rate, the activity of the Kr^{88} parent and then that of the entire mixture of fission nuclides was calculated, taking into account the time of neutron irradiation of the uranium used in the preparation, growth and decay relations, and the relative fission yields of the various rare gas species. Of the many fission-gas nu-

[19] H. Lange, Z. Hochfrequenz. **31**, 105, 133, 191 (1928); see also, K. R. Spangenberg, *Vacuum Tubes* (McGraw-Hill Book Company, Inc., New York, 1948), pp. 214–8.

[20] See H. S. W. Massey and E. H. S. Burhop, *Ionic and Electronic Impact Phenomena* (Clarendon Press, Oxford, 1952), Chaps. 2, 4, and 8.

[21] C. J. Borkowski, U. S. Atomic Energy Commission Report MDDC-1099 (unpublished).

clides, only the five in Table I were considered to comprise the mixture used, since calculations revealed these to contribute measurably to the positive ion current under the conditions of this experiment.

The A^{41} was counted, after dilution with inactive argon carrier, in a small external gas cell patterned after one described by Rosen and Davis.[22] Geometrical conditions described by these authors were followed in detail. Corrections were made for scattering and absorption of the 1.2-Mev betas from A^{41}.

A^{37} and Kr^{83m} activities were measured, after dilution, in proportional counters, using a 90-percent argon —10-percent methane counting mixture.[23] Counters of varying cathode length and diameter gave indistinguishable specific counting rates for several active samples.

The disintegration rate of the 4.4-hr $C_2H_5Br^{80m}$ was obtained from the activity of its 18-min daughter in a manner similar to that described for the $Kr^{88}-Rb^{88}$ pair. The chemical procedure is described elsewhere.[3]

Except for T_2 and $C^{14}O_2$, the decrease in counting rate of the aliquot sample with time was compared with the known half-life of the nuclide in question and found to agree within a few percent.

TABLE I. Decay characteristics of fission gases contributing to positive ion current.[a]

Radionuclide	$t_{\frac{1}{2}}$ (hr)	Radiation	Fission yield (%)	Energy of radiation (Mev) Particles	γ-rays
$_{36}Kr^{83}$	1.89	I.T., γ, e^-	0.4	···	0.0327; 0.0093
Kr^{85}	4.5	β^-, γ	1.0	0.86	0.15; 0.305
Kr^{87}	1.25	β^-, γ	2.8	3.63; 1.27	0.41; 1.89; 2.3
Kr^{88}	2.77	β^-, γ	4.0	2.8; 0.9; 0.52	0.028
$_{54}Xe^{135}$	9.2	β^-, γ	5.9	0.905	0.25

[a] This table was assembled from data compiled in Hollander, Perlman and Seaborg, Rev. Mod. Phys. 25, 469 (1953).

3. Preparation of Active Gases

Activation and chemical procedures were employed which yielded gases in the high specific activities required to obtain measurable positive ion currents. The $C^{14}O_2$ was prepared from 15.1-percent enriched $BaC^{14}O_3$ by the method described by Greiner *et al.*[24] A sample of tritium gas, available in this laboratory, was used in the T_2 beta-decay studies. The mixture of active krypton and xenon was separated from neutron-irradiated uranium: Uranyl nitrate, placed in the Argonne heavy water reactor for three hours, was dissolved in previously outgassed water in an evacuated system. The mixture was heated to facilitate dissolving of the salt and to drive off the fission gases. The solution was then frozen-out, and the gas was passed through dry ice and liquid-nitrogen-cooled traps and collected in a large flask. Pure argon gas was placed in the pile to obtain A^{41}.

The 35-day nuclide A^{37} was separated from neutron-irradiated calcium metal by vacuum fusion. Ethyl bromide tagged with 4.4-hr Br^{80m} was prepared by photochemical addition of ethylene gas to neutron-activated hydrogen bromide. To prepare Kr^{83m}, pile-irradiated selenium metal was dissolved in nitric acid, and Br^- carrier was then added to the diluted solution. Se^{83} was permitted to decay into Br^{83} for one-half hour, after which the Br^{83} activity and carrier were extracted as Br_2 into CCl_4 by permanganate oxidation, and then returned to dilute NH_4OH. The solution was evaporated to dryness, and the flask containing the NH_4Br residue was attached to a vacuum system. After 2.5 hours' standing to allow formation of Kr^{83m}, the active noble gas was removed by vacuum sublimation of the NH_4Br.

TABLE II. Average charge of recoils after β^- decay of tritium.

Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of tritium in ion collection chamber	Average positive charge per disintegration (electron units)
1.6×10^{-12}	1.1×10^{7}	1.3×10^{7}	0.9
5.4×10^{-12}	3.8×10^{7}	3.8×10^{7}	1.0
3.1×10^{-12}	2.2×10^{7}	2.4×10^{7}	0.9
7.1×10^{-12}	5.0×10^{7}	5.5×10^{7}	0.9
4.5×10^{-12}	3.2×10^{7}	3.6×10^{7}	0.9

[a] The values listed have been corrected for interception of positive ions by the grid and chance interception of fast electrons by the collector.

TABLE III. Average positive charge after beta decay of $C^{14}O_2$.

Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of C^{14} in ion collection chamber	Average positive charge per disintegration (electron units)
9.5×10^{-15}	6.7×10^{4}	8.48×10^{4}	0.8
1.6×10^{-14}	1.1×10^{5}	9.42×10^{4}	1.2
1.6×10^{-14}	1.1×10^{5}	1.13×10^{5}	1.0

[a] See footnote, Table II.

[22] F. D. Rosen and W. Davis, Jr., U. S. Atomic Energy Commission Report AECD-3184 (unpublished).

[23] These counters are described by S. Katcoff, Phys. Rev. 87, 886 (1952) and R. Ballentine and W. Bernstein, Rev. Sci. Instr. 21, 158 (1950). The counters exhibited two-step plateaus with internal A^{37} samples. The first step was approximately 13 percent below the plateau at higher operating voltages. Reduction of the amplifier gain by factors of 5 or 10 lowered the counting rates by ~15 percent when the counter voltage was held in the middle of the higher plateau. Further, pulse heights at the higher voltage were about 10 times those corresponding to the lower step. Consequently, it was decided that in addition to the 2.6-kev Auger electron following K capture in A^{37}, electrons of ~200 ev were also counted at the higher voltage plateau. Despite escape of K fluorescence radiation from the counter, disintegrations involving K capture and subsequent radiation would be detected by 200-ev M-shell Auger electrons. Similarly, the 280 ev available from L_1-capture would be dissipated in the counter as an M electron and thus be detected. With counting conditions similar to those employed here, Kirkwood, Pontecorvo, and Hanna, Phys. Rev. 74, 497 (1948), observed electrons of 200 ev in the A^{37} decay. Disintegration rate measurements on the Kr^{83m} samples present no apparent difficulty. Auger electrons from either the 32.7- or 9.3-kev transitions would be detected in the proportional counters used.

[24] Greiner, Hamill, Inghram, and Libby, Phys. Rev. 75, 1825 (1949).

TABLE IV. Charge borne by potassium atoms from beta decay of A^{41}.

Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of A^{41} in ion collection chamber	Average positive charge per disintegration (electron units)
3.6×10^{-14}	2.7×10^{5}	3.1×10^{5}	0.9
2.4×10^{-14}	1.8×10^{5}	1.6×10^{5}	1.1
3.2×10^{-14}	2.4×10^{5}	2.1×10^{5}	1.1
3.8×10^{-14}	2.8×10^{5}	3.1×10^{5}	0.9
3.5×10^{-14}	2.6×10^{5}	2.6×10^{5}	1.0
3.4×10^{-14}	2.6×10^{5}	2.6×10^{5}	1.0
1.5×10^{-14}	1.1×10^{5}	9.6×10^{4}	1.1

[a] See footnote, Table II.

C. RESULTS AND DISCUSSION

1. Beta-Decay Studies

Tables II through V contain the results on the average positive charge of the recoils from β^- decay of T_2, $C^{14}O_2$, A^{41}, and of the mixture of fission gases, respectively. The charge carried by the products of the tritium decay is within experimental error of one positive electron unit, the minimum expected in a negative beta transition. Unfortunately, no theoretical discussion of the probability of electron ejection has been forthcoming for β^- emission in molecular tritium. Migdal's relations[10] are applicable to atomic tritium; an average charge of $+1.03$ is calculated for the He^3 daughter. Because of the low currents measured in the $C^{14}O_2$ studies (Table III), the data are scattered, but the indication is lack of measurable shell ionization in this beta transformation. For comparison purposes, a charge of $+1.1$ has been calculated for the N^{14} recoil from β^- decay of a C^{14} atom, using equations developed by Levinger.[14]

The seven determinations of the charge of K^{41} atoms after beta emission by A^{41} (Table IV) indicate $+1.0\pm0.1$ as the average. Using relations presented by Schwartz[13] with the assumption that the nuclear charge of the potassium daughter ($Z=19$) is "high," we estimate the average charge to be $+1.1$ electron units.

The more extensive study of the mixture of fission gases (Table V) indicates the average charge carried by the Rb and Cs recoils to be somewhat higher than one positive unit. Within the precision of this measurement, similar results were obtained with the sphere and cylinder and with repeller grids of widely differing open area. It would appear that the experimental result is not decisively determined by the geometry of the apparatus. Further evidence to support this view is presented under the results of the Br^{80m} studies (see below). That the charge is slightly higher than one positive may be due to partial internal conversion of low-energy γ-rays accompanying the betas from several nuclides in the mixture (Table I). Since conversion can initiate loss of several orbital electrons, a small fraction of the daughter atoms may have high positive charges, and the average may then be greater than that from the beta process alone. Crude estimates, based on known conversion coefficients and assumptions regarding the number of electrons lost in the process, suggest that about 0.5 electron unit of charge per disintegration is attributable to internal conversion of soft gammas. Correcting for internal conversion in this way, the average charge due only to the beta transitions varies between 0.3 and $1.2e$ with an average of 0.8 positive units. Within experimental error, the corrected data fail to show loss of orbital electrons in the beta process and are in agreement with the findings on Nr^{88}.[4] The complicating feature of conversion is not present in the other beta transitions reported on.

The results of these decay studies indicate that ionization of orbital electrons does not occur to a significant extent in the negative beta process. However, the experiment at present lacks sufficient precision to detect the small effects predicted.

2. Isomeric Transitions of 4.4-hr Br^{80m} and 113-min Kr^{83m}

The decay of 4.4-hr Br^{80m} to its 18-min isomer proceeds by two successive transitions: a 47-kev step, completely converted, is followed by one of 37 kev, the latter 57 percent converted.[25] Deep-lying shell vacancies

TABLE V. Charge of recoil atoms after decay of fission gases.

Geometry of ion collection chamber	Fractional open area of grid	Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Rb^{88} activity (dis/sec)	Dis/sec of Kr^{88} in ion collection chamber	Activity of fission gas mixture (dis/sec)	Average positive charge per disintegration (electron units)
Sphere	0.65	8.7×10^{-15}	8.5×10^{4}	2070	2.86×10^{4}	5.0×10^{4}	1.7
Sphere	0.65	2.9×10^{-14}	2.8×10^{5}	3320	8.16×10^{4}	1.8×10^{5}	1.6
Sphere	0.65	6.0×10^{-15}	5.8×10^{4}	2232	3.01×10^{4}	7.1×10^{4}	0.8
Sphere	0.65	1.1×10^{-14}	1.1×10^{5}	2868	3.97×10^{4}	9.4×10^{4}	1.2
Cylinder	0.88	5.5×10^{-14}	3.9×10^{5}	4980	1.10×10^{5}	2.4×10^{5}	1.6
Cylinder	0.88	1.7×10^{-14}	1.2×10^{5}	1681	3.38×10^{4}	8.0×10^{4}	1.5
Cylinder	0.88	1.0×10^{-14}	7.2×10^{4}	1208	2.57×10^{4}	6.1×10^{4}	1.2
Sphere	0.89	1.7×10^{-14}	1.2×10^{5}	3100	4.24×10^{4}	9.7×10^{4}	1.2
Sphere	0.89	7.4×10^{-15}	5.2×10^{4}	1130	2.10×10^{4}	4.9×10^{4}	1.1
Sphere	0.89	1.5×10^{-14}	1.1×10^{5}	1807	3.76×10^{4}	8.8×10^{4}	1.3

[a] See footnote, Table II.

[25] P. Rothwell and D. West, Proc. Phys. Soc. (London) **A63**, 539 (1950).

TABLE VI. Average charge of product atoms from isomeric transition of Br^{80m}.

Geometry of ion collection chamber	Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of Br^{80m} in ion collection chamber	Average positive charge per disintegration (electron units)
Sphere	7.0×10^{-14}	6.7×10^{5}	7.4×10^{4}	9
Sphere	5.4×10^{-14}	5.2×10^{5}	4.7×10^{4}	11
Sphere	4.2×10^{-14}	4.0×10^{5}	4.7×10^{4}	9
Sphere	3.9×10^{-14}	3.8×10^{5}	4.9×10^{4}	8
Sphere	4.4×10^{-14}	4.2×10^{5}	4.3×10^{4}	10
Sphere	3.7×10^{-14}	3.5×10^{5}	3.2×10^{4}	11
Sphere	3.9×10^{-14}	3.8×10^{5}	4.6×10^{4}	8
Sphere[b]	1.0×10^{-13}	9.6×10^{5}	9.1×10^{4}	11
Sphere[b]	5.4×10^{-14}	5.2×10^{5}	6.0×10^{4}	9
Cylinder	4.58×10^{-14}	2.95×10^{5}	2.32×10^{4}	13
Cylinder	7.95×10^{-14}	5.12×10^{5}	4.92×10^{4}	10
Cylinder[b]	7.84×10^{-14}	5.05×10^{5}	4.75×10^{4}	11
Cylinder[b]	8.73×10^{-14}	5.62×10^{5}	4.45×10^{4}	13

[a] See footnote, Table II.
[b] Cu cylinders, rather than Pyrex flasks, were used in the disintegration rate determinations.

which result are filled by subsequent Auger and radiative electron transitions. The cumulative result of these electron cascades is a bromine ion of high positive charge. Cooper,[9] considering all possible Auger transitions except those of the Coster-Kronig type, has calculated an average of $+4.7e$ for a Br atom which has suffered internal conversion in the K orbit. This result has been extended by taking into account the K and L conversions of the two stepwise transitions of Br^{80m}; an average charge of 6.3 units is calculated. The experimental findings appear in Table VI. The average charges listed in the final column are seen to be about 10 positive units, individual results varying from 8 to 13e. The data from the sphere with 65-percent open grid area and cylinder with 88-percent open area are again similar. In several experiments, glass bulbs of various volumes were used as the decay vessels instead of copper cylinders. Results from the two procedures appear to be indistinguishable. The finding is about twice that predicted, but in view of the uncertainties in the calculation and the experimental necessity of incorporating the Br^{80m} in an organic molecule, the difference may not be surprising.

The isomeric decay of Kr^{83m} resembles the Br^{80m} transition closely, for the 32.7- and 9.3-kev steps of the former are in cascade and are highly converted.[26,27] Results of this study appear in Table VII. The average positive charge on the Kr^{83} atom following this isomeric change is observed to be $7.7\pm0.4e$.

TABLE VII. Electric charge produced in isomeric decay of Kr^{83m}.

Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of Kr^{83m} in ion collection chamber	Average positive charge per disintegration (electron units)
2.95×10^{-13}	2.18×10^{6}	2.96×10^{5}	7.4
1.69×10^{-13}	1.26×10^{6}	1.58×10^{5}	8.0
9.9×10^{-14}	7.4×10^{5}	9.9×10^{4}	7.5
2.27×10^{-13}	1.68×10^{6}	2.08×10^{5}	8.0
1.37×10^{-13}	1.01×10^{6}	1.33×10^{5}	7.6
7.6×10^{-14}	5.6×10^{5}	7.5×10^{4}	7.5

[a] See footnote, Table II.

TABLE VIII. Charge carried by chlorine recoils from electron capture of A^{37}.

Positive ion current (amp)	Positive charges collected per second[a] (electron units)	Dis/sec of A^{37} in ion collection chamber	Average positive charge per disintegration (electron units)
9.7×10^{-13}	7.3×10^{6}	2.67×10^{6}	2.7
2.77×10^{-13}	2.09×10^{6}	6.49×10^{5}	3.2
1.89×10^{-13}	1.42×10^{6}	4.47×10^{5}	3.2
8.1×10^{-14}	6.1×10^{5}	2.18×10^{5}	2.8
6.5×10^{-14}	4.9×10^{5}	1.74×10^{5}	2.8
5.3×10^{-14}	4.0×10^{5}	1.31×10^{5}	3.1

[a] See footnote, Table II.

3. Orbital Electron Capture by 35-day A^{37}

Atomic reorientation following electron capture is similar to that accompanying the internal conversion process. From calculations of Primakoff and Porter,[28] orbital ionization caused by sudden change in nuclear charge in electron capture is apparently extremely small for the A^{37} transition. However, Auger transitions can increase the initial zero charge of the daughter to rather high values. The average charge carried by the chlorine atoms from electron capture in 35-day A^{37} is seen from the data of Table VIII to be 3.0 ± 0.2 positive electron units. The result agrees well with $3.41\pm0.14e$ reported by Miskel and Perlman for this transformation.[15] A theoretical estimate of the charge after orbital capture of A^{37} may be made from Auger transition probabilities presented by Pincherle.[29] A value of $+2.36$ electron units is calculated. Account was taken of L capture[30] in A^{37} and of the K fluorescence yield of chlorine.[31] However, Pincherle neglects Auger transitions of the Coster-Kronig type, and, unfortunately, information on the particular transitions of interest here has not appeared elsewhere in the literature. If it is assumed that each L_{I} hole is filled by an L_{II} or L_{III} electron with the ejection of an M electron, the calculated average increases to $2.7e$.

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