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Abstract

Full Text

Physics

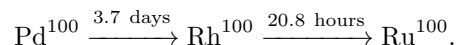
N. M. Anton'eva, Corresponding Member of the Academy of Sciences of the USSR B. S. Dzhelepov, G. S. Katykhin, V. B. Smirnov

Study of the Decay of Rh¹⁰⁰

The radiation of the isotope Rh¹⁰⁰ was investigated by means of a magnetic spectrometer of the "Kättron" type with scintillation registration of electrons ($\Delta H\rho/H\rho = 0.5\%$) and scintillation γ -spectrometers: a single spectrometer, a coincidence spectrometer ($2\tau = 5 \cdot 10^{-8}$ sec), and a total-absorption spectrometer with a NaI crystal with a well.

The isotope Rh¹⁰⁰ was obtained either by the reaction $\text{Ag} + \text{p}$ (660 MeV), or as the daughter product of the decay of Pd¹⁰⁰ (¹).

According to (^{1,2}), the following decay chain occurs:



Thus, by chemically separating the Rh fraction on fluoroplastic-4, we obtained Rh¹⁰⁰ either mixed with other Rh isotopes, or Rh¹⁰⁰ in equilibrium with Pd¹⁰⁰, or (by separating Rh from Pd 3-4 days after irradiation of the target) pure Rh¹⁰⁰.

Identification of the observed γ transitions was carried out by observing the growth and decay of the intensities of the γ lines and of some conversion lines in the Pd and Rh fractions.

Analysis of the corresponding curves obtained for the Pd fraction (the Pd fraction was separated ~ 5 days after irradiation of the target) gave, respectively, the values $T_{1/2} \simeq 20$ hours and 3.7 days. The intensity of these same γ lines in the Rh fraction decayed with $T_{1/2} \simeq 20$ hours. From these data it follows that the corresponding γ transitions belong to the decay of Rh¹⁰⁰. In addition, for a number of γ transitions the values $K - L$ were determined, proving their assignment to the decay of the Rh isotope.

For the half-life of Rh¹⁰⁰, from the study of the conversion-electron spectrum we obtained the value 18 ± 1 hours (in (¹) the value $T_{1/2} = 20.8$ hours is apparently overestimated because of the presence of an admixture of Pd¹⁰⁰).

Investigation of the conversion-electron spectrum of Rh¹⁰⁰ revealed the presence of a number of groups of closely spaced lines; the energies of the corresponding γ

transitions, the values $K-L$, K/L , and the relative intensities of the conversion electrons are given in Table 1.

Before the present work, the conversion-electron spectrum of Rh^{100} had been investigated only in ⁽¹⁾, with an instrumental resolution of $\simeq 3.5\%$; the authors detected about 10 γ transitions. In the present work about 60 new γ transitions belonging to the decay of Rh^{100} were discovered. In studying the γ spectra of Rh^{100} , such complexity of the spectrum must be taken into account. The results of work ⁽³⁾ on the γ radiation of Rh^{100} can be considered only with respect to entire groups of lines which the authors of ⁽³⁾ took to be single lines.

In the present work, in studying the γ - γ coincidence spectra of Rh^{100} , small energy regions of the γ spectrum, ~ 20 -40 keV, were fixed, and their coincidence with the rest of the γ spectrum was studied. In this way the energy range from 200 to 2500 keV was analyzed in detail. The results obtained are presented in Table 2. They are in good agreement with the data of the conversion spectrum and confirm the complex structure of individual groups of lines. Thus, for example, from the results obtained from the γ - γ coincidence spectrum it follows that there are at least 3 components of the 1360-keV group, 2 of which are in cascade, while the 3rd coincides with neither of the first two.

To the article by N. M. Anton'eva, B. S. Dzhelepov, G. S. Katykhin, and V. B. Smirnov

Visible labels in the decay scheme:

- 543
- $E2$
- 538 ($E2$)
- 1082
- 234
- 287
- 826
- $[[unclear : gamma - rayenergy]]$
- 329
- 908
- 1347
- 1800
- 742
- 855
- 1030
- 1570
- 2170
- 368
- 581
- 112
- 1205
- 1490

- 1930
- 2480
- 428
- 658
- 1180
- 1270
- 584
- 803
- 1420
- 1620
- 2700
- 302
- 670
- 890
- 1417
- 2240
- 2780
- 451
- 818
- 1040
- 1560
- 1652
- 2385
- 2930
- 438
- 512
- 877
- 1098
- 1620
- 340
- 427
- 574
- 837
- 1006
- 1225
- 1750
- 3100
- 297
- 445
- 530
- 660
- 747
- 1333
- 3230
- 387
- 534

- 619
- 837
- 1205
- 1420
- 3330
- 438
- 500
- 649
- 877
- 947
- 1318
- 1540
- 3430

Nuclide label visible at left:



Beta-transition labels visible at bottom:

$$\beta^+ 2680$$

2120, 1600, 1300, 800, 380, 200

Right-side label:

$$\beta^+$$

Half-life label:

$$18 \pm 1 \text{ h}$$

Table 1

Energies of γ transitions; values of $K-L$, K/L ; relative intensities of conversion electrons; energies of sum transitions of Rh^{100}

No.	Energy of conversion electrons E_e , keV	Interpretation	$K - L$, keV	Relative intensity of conversion electrons		$h\nu$, keV, conversion	$h\nu$, keV, γ spectrum	Energy of sum γ transitions, keV		Rel. intensity of conversion electrons ⁽¹⁾
								$h\nu$, keV, ⁽¹⁾		
1	265 ± 2	<i>K</i>	—	—	287 ± 2	—	—	—	—	
2	275 ± 2	<i>K</i>	—	4 ± 1	297 ± 2	—	—	—	—	
3	280 ± 2	<i>K</i>	—	2.0 ± 0.6	302 ± 2	300	—	301.2	5.3	
4	294 ± 2	<i>L 297</i>	—	1.6 ± 0.4	—	—	—	—	—	
5	318 ± 2	<i>K</i>	—	0.6	340 ± 2	—	—	—	—	
6	346 ± 2	<i>K</i>	—	1 ± 0.3	368 ± 2	365	—	370	0.9	
7	405 ± 2	<i>K</i>	—	2.5 ± 0.5	427 ± 2	—	—	—	—	
8	416 ± 2	<i>K</i>	—	5 ± 1	438 ± 2	440	—	—	—	
9	423 ± 2	<i>K</i>	19.5 ± 1 (5.0)	7 ± 1	445 ± 2	—	—	442.4	21.3	
10	429 ± 2	<i>K</i>	19.2 ± 1 (6.0)	18 ± 2	451 ± 2	—	—	—	—	
11	442 ± 3	<i>L 445</i>	—	1.5 ± 0.3	—	—	—	—	—	
12	448 ± 1	<i>L 451</i>	—	3.0 ± 1	—	—	—	—	—	
13	478 ± 2	<i>K</i>	—	2 ± 0.4	500 ± 2	—	—	—	—	
14	490 ± 2	<i>K</i>	—	0.7 ± 0.3	512 ± 2	—	—	—	—	
15	498 ± 2	<i>K</i>	—	4 ± 1	520 ± 2	—	—	—	—	
16	$502 \pm 2?$	<i>K</i>	—	3.5 ± 1	524 ± 2	—	—	—	—	
17	508 ± 3	<i>K</i>	—	5 ± 1	530 ± 3	—	—	—	—	

No.	Energy of conversion electrons E_e , keV	Interpretation	Relative intensity of conversion electrons		$h\nu$, keV, conversion	$h\nu$, keV, γ spectrum	Energy of sum γ transitions, keV		Rel. intensity of conversion electrons (1)
			$K - L$, keV	K/L			$h\nu$, keV, (1)	$h\nu$, keV, (1)	
18	512±2	<i>K</i>	—	9 ± 2	534 ± 2	—	—	—	—
19	516±2	<i>K</i>	19 ± 0.7 (6.0)	35 ± 5	538 ± 2	540 complex	540	535.3	100
20	521±2	<i>K</i>	19 ± 0.7 (6.0)	100 ± 5	543 ± 2	—	—	—	—
21	535±2	<i>L</i> 538	—	6 ± 1	—	—	—	—	—
22	540±2	<i>L</i> 543	—	15 ± 2	—	—	—	—	—
23	562±3	<i>K</i>	18.5 ± 1 (3.0)	2.5 ± 0.3	584 ± 3	600	—	—	—
24	569±2	<i>K</i>	19 ± 1 (3.0)	4.0 ± 0.5	591 ± 2	—	—	—	—
25	578±2	<i>L</i> 584	—	1.0 ± 0.3	—	—	—	—	—
26	588±1	<i>L</i> 591	—	1.5 ± 0.3	—	—	—	—	—
27	597±2	<i>K</i>	—	1.7 ± 0.3	619 ± 2	—	—	—	—
28	617±2	<i>K</i>	—	1.5 ± 0.3	639 ± 2	—	—	—	—
29	627±2	<i>K</i>	—	1.6 ± 0.3	649 ± 2	650	—	—	—
30	636±2	<i>K</i>	—	1.6 ± 0.3	658 ± 2	—	—	—	—
31	648±3	<i>K</i>	—	0.9 ± 0.2	670 ± 3	—	—	—	—
32	658±3	<i>K</i>	—	1.6 ± 0.3	680 ± 3	—	—	—	—
33	712±2	<i>K</i>	—	1.0 ± 0.2	734 ± 2	740	—	—	—
34	720±3	<i>K</i>	—	0.6 ± 0.2	742 ± 3	—	—	742.4	0.6

No.	Energy of conversion electrons E_e , keV	Interpretation	$K - L$, keV	Relative intensity of conversion electrons		$h\nu$, keV, conversion	$h\nu$, keV, γ spectrum	Energy of sum γ transitions, keV		Rel. intensity of conversion electrons ⁽¹⁾
				K/L	electrons			$h\nu$, keV, ⁽¹⁾		
35	725±3	<i>K</i>	—	0.5 ± 0.2	747 ± 3	—	—	—	—	
36	781±3	<i>K</i>	—	0.4 ± 0.1	803 ± 3	—	—	—	—	
37	786±3	<i>K</i>	—	0.8 ± 0.2	808 ± 3	—	—	—	—	
38	797±3	<i>K</i>	—	3.0 ± 0.4	818 ± 3	820 complex	—	—	—	
39	804±2	<i>K</i>	20±2	9 ± 1	826 ± 2	—	—	822.5	9.7	
40	814±4	<i>K</i>	—	3.5 ± 0.6	835 ± 4	—	—	—	—	
41	824±2	<i>L</i> 826	—	—	—	—	—	—	—	
42	853±3	<i>K</i>	—	0.9 ± 0.2	877 ± 3	—	—	—	—	
43	867±1	<i>K</i>	—	1.1 ± 0.3	890 ± 3	—	—	—	—	
44	907±3?	<i>K</i>	—	0.7 ± 0.2	929 ± 3	—	—	—	—	
45	925±3	<i>K</i>	—	0.7 ± 0.2	947 ± 3	—	—	—	—	
46	984±4	<i>K</i>	—	0.6 ± 0.2	1006±4	1040	—	—	—	
47	1020±4	<i>K', K</i>	—	0.6 ± 0.2	1040±4	—	—	—	—	
	double									
48	1060±4	<i>K</i>	—	0.7 ± 0.2	1082±4	—	1080	—	—	
49	1076±3	<i>K</i>	—	0.9 ± 0.2	1098±3	—	—	—	—	
50	1090±3	<i>K</i>	—	1.5 ± 0.2	1112±3	1120	—	1108	1.5	

No.	Energy of conversion electrons E_e , keV	Interpretation	$K - L$, keV	Relative intensity of conversion electrons		Energy of sum γ transitions, keV			Rel. intensity of conversion electrons ⁽¹⁾
				$h\nu$, keV, conversion	$h\nu$, keV, γ spectrum	$h\nu$, keV, ⁽¹⁾	$h\nu$, keV, ⁽¹⁾	$h\nu$, keV, ⁽¹⁾	
51	1109 \pm 3	<i>L</i> 1112	—	0.4 \pm 0.1	—	—	—	—	—
52	1183 \pm 3	<i>K</i>	—	0.5 \pm 0.1	1205 \pm 3	—	—	—	—
53	1203 \pm 4	<i>K</i>	—	0.7 \pm 0.2	1225 \pm 5	—	—	—	—
54	1296 \pm 3	<i>K</i>	—	0.3 \pm 0.1	1318 \pm 3	—	—	—	—
55	1314 \pm 4	<i>K</i>	—	0.6 \pm 0.2	1335 \pm 4	1360 complex	1360	1358.2	2.8
56	1325 \pm 4	<i>K</i>	—	1.3 \pm 0.2	1347 \pm 4	—	—	—	—
57	1347 \pm 4	<i>K</i>	—	3.0 \pm 0.5	1369 \pm 4	—	—	—	—
58	1344 \pm 4	<i>L</i> 1347	20 \pm 2	—	—	—	—	—	—
59	1366 \pm 3	<i>L</i> 1369	19.7 \pm 1	—	—	—	—	—	—
60	1380 \pm 5	<i>K</i>	—	0.5 \pm 0.2	1400 \pm 5	—	—	—	—
61	1395 \pm 5	<i>K</i>	—	0.2 \pm 0.1	1417 \pm 5	—	—	—	—
62	1409 \pm 5	<i>K</i>	—	0.3 \pm 0.1	1420 \pm 5	—	—	—	—
63	1519 \pm 5	<i>K</i>	—	0.3 \pm 0.1	1540 \pm 5	1560 \pm 20 complex	—	—	—
64	1540 \pm 5	<i>K</i>	20 \pm 2 (4.0)	0.8 \pm 0.2	1560 \pm 5	—	—	1557.4	1.7
65	1548 \pm 4	<i>K</i>	19.5 \pm 2 (4.0)	1.2 \pm 0.2	1570 \pm 4	—	—	—	—
66	1558 \pm 4	<i>L</i> 1560	—	0.2 \pm 0.1	—	—	—	—	—

No.	Energy of conversion electrons E_e , keV	Interpretation	$K - L$, keV	Relative intensity of conversion electrons	$h\nu$, keV, conversion	$h\nu$, keV, γ spectrum	Energy of sum γ transitions, keV		Rel. intensity of conversion electrons ⁽¹⁾
							$h\nu$, keV, ⁽¹⁾	$h\nu$, keV, ⁽¹⁾	
67	1568±3	L 1570	—	0.3 ± 0.1	—	—	—	—	—
68	1597±5	K	—	0.4 ± 0.1	1620±5	1620±20	—	—	—
69	1630±5	K	—	0.4 ± 0.2	1652±5	—	—	—	—
70	1728±7	K	—	0.2	1750±7	1890 complex	1890	—	—
71	—	—	—	—	—	1930 complex	—	1934.1	0.1
72	—	—	—	—	—	2110	2110	—	—
73	—	—	—	—	—	2380±30	—	2379	1.0
74	2363±7	K	—	—	2385±7	2480±50	2480	—	—
75	—	—	—	—	—	2700±30	2700	—	—
76	—	—	—	—	—	2780±30	2780	—	—
77	—	—	—	—	—	2930±30	~ 2930 complex	—	—
78	—	—	—	—	—	3100±50	3100±	—	—
79	—	—	—	—	—	3250±50	3220±	—	—
80	—	—	—	—	—	3330±60	3300±	—	—
81	—	—	—	—	—	3430±60	3400±	—	—
82	—	—	—	—	—	—	—	—	—

In the spectrum of conversion electrons, 4 lines with close energies were indeed found (see Tables 1 and 2). All these facts are reflected in the proposed decay scheme of Rh^{100} (see Fig. 1).

The hard γ -radiation of Rh^{100} was studied with Pb filters ($l = 5$ cm). Ten new lines were found, apparently corresponding to direct γ -transitions from excited states to the ground state.

Table 2

Results of the study of the γ - γ -coincidence spectra of Rh^{100}

Fixed γ -transition, $h\nu$, keV	γ -transitions coincident with the data *, $h\nu$, keV
540	2380, 2100, 1930, 1560, 1360 left, 1110, 1040, 820, 540, 440, 300. No γ - γ with 1360 right.
820 right	1560, 1110, 820 left, 540 right, 440, 300. No γ - γ with 1900 and above
820 left	2100, 1560, 1360, 820 right, 540, 300. No γ - γ (440) and above 2100
1040	1360 left, 1110, 820 left, 540, 440. No γ - γ with 1560 and above
1110	1360 right, 1040, 820 right, 540, 440, 300. No γ - γ with 1560
1360 right	1560, 1110, 820 left, 540, 440, 300. No γ - γ with 1360 left and above 1560
1360 left	1360 left, 1040, 820, 540, 440, 300. No γ - γ with 1560, 1360 right
1560	1360, 820, 540, 440, 300. No γ - γ 1560, 1110, 1040
2100	1000, 820 left, 600, 540 left, 440, 300
2380	540, 300

* The designations right and left for complex γ -lines in coincident γ -transitions are not given in those cases when coincidences with several components of the γ -line are observed.

To obtain information on the energies of the levels of Ru^{100} , the Rh^{100} source was placed in the well of an NaJ crystal and outside it; the rise and fall of the intensity of the “sum lines” were observed, and their assignment to Rh^{100} was shown.

The energies of the sum γ -transitions are given in Table 1.

From the data we obtained on the β^+ -spectrum of Rh^{100} , one may assume the existence of two new components of the β^+ -spectrum. In Fig. 1 they are shown

by dashed lines.

On the basis of the totality of the results obtained, the decay scheme of Rh^{100} shown in Fig. 1 is proposed.

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named after A. A. Zhdanov

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3. B. Basu, A. P. Patro, Nuclear Phys. **29**, 672 (1962).

Note: Figure translations are in progress. See original paper for figures.

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