Some Isotopes of Platinum and Gold

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A SURVEY of the lighter radioactive isotopes of platinum and gold has been made. Using the 60-inch Crocker Laboratory cyclotron, bombardments were made of iridium, with 38-Mev helium ions and 18-Mev deuterons, of platinum with 18-Mev deuterons, fast and thermal neutrons, and of gold with fast neutrons. After bombardments, the metal targets used were dissolved and radioactive isotopes separated by the usual carrier techniques. Iridium metal was dissolved by heating for a few hours at 300°C, with strong hydrochloric acid and sodium chlorate in a sealed tube.[1] Chemical separations of osmium, iridium, platinum, and gold were made using variations of the basic procedures: (*a*) distillation of osmium as tetroxide from nitric acid solution, (*b*) ethyl acetate extraction of gold in the oxidized state, with reduction to the metal by sulfur dioxide, (*c*) ethyl acetate extraction of platinum in the divalent state after reduction by stannous chloride,[2] (*d*) precipitation of iridium as potassium chloroiridate or as the dioxide.

Table I summarizes the properties of the longer lived gold and platinum isotopes of mass below 197, which have been here studied. The radiations are consistent with the assumption of decay by orbital electron capture, electrons arising from gamma-ray conversions in transitions from excited states of the product nuclei. Electron and soft electromagnetic radiations were resolved using the technique of differential absorption in the thin foils of aluminum and beryllium. Energies of radiations were obtained from absorption measurements.

In addition to the isotopes listed, the previously known[3] activities of Ir^{192} (70 days), Ir^{194} (19 hours), and Pt^{197} (18 hours), Pt^{199} (31 minutes) were obtained in good yields by d, p reactions on iridium and platinum. In addition, very low yields of Os^{191} (32 hours), Ir^{192}, and Ir^{194} were observed by the respective d, α reactions in iridium and platinum.

4.33-day platinum.—A platinum isotope with radiations similar to the one now observed has been reported previously[4] and allocated to Pt^{197},[3] but a half-life of about three days was given. In the present work the electrons and quantum radiation decay with the same half-life which has been measured through fourteen half-lives. The activity is attributed to Pt^{193} decaying by orbital electron capture for the following reasons. The isotope is formed in the deuteron, fast and thermal neutron bombardments of platinum, and also in the deuteron and α-particle bombardments of iridium in yields agreeing with allocation to mass 193. No iridium daughter activity of half-life greater than a few minutes has been found. There is no evidence for its formation in the decay of Ir^{194}. Separation of platinum from the gold fractions of both Pt+d and Ir+α bombardments show the growth of the 4.3-day activity from a parent of half-life 16±1 hours.

3.0-day platinum.—Previously unreported, this isotope which is distinguished from the 4.3-day isotope by its 0.5-Mev electron and strong 0.57-Mev γ-ray has been observed in low yield in Pt+d, Pt+fast neutron, and Ir+α bombardments, but in a yield comparable to that of the 4.3-day activity in the deuteron bombardment of iridium. No daughter activity has been observed. Growth of the 3.0-day activity from a parent of ~1-day half-life occurred in gold fractions from both Pt+d and Ir+α bombardments, together with the 4.3-day activity, but in a much lower yield. The electrons and electromagnetic radiation decay with the same half-life which has been followed through eight half-lives. The activity has been assigned provisionally to mass 191.

If the 3 and 4.3-day activities are correctly allocated to masses 191 and 193, respectively,

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[4] a. R. S. Krishnan and E. A. Nahum, Proc. Camb. Phil. Soc. **37**, 422 (1941); b. E. M. McMillan, M. Kamen, and S. Ruben, Phys. Rev. **52**, 375 (1937).

no activity of Pt^{190} formed by Ir d, $3n$ reaction has been observed, although this reaction would be expected to occur; the 10.7-day Ir^{190} isotope[5] which should be present in the iridium fraction if Pt^{190} had a short half-life was not found. Pt^{190} might be expected to have a long life and the results thus are not inconsistent with this consideration.

190-day gold.—A long-lived gold activity has been detected previously,[4a, 6] but has not been adequately characterized. This activity is produced in high yield in both Pt+d and Ir+α bombardments. The radiations and decay appear identical in both cases, but measurements have been made as yet only through just over one half-life. A sample of ~0.4-millicuries strength with high specific activity was prepared from a platinum target which had received 492 microamperes of deuterons over a period of three months, and had been decaying for four months. No evidence of any activities of half-lives between those of the 5.5-day and 190-day isotopes has been found, and the radiation characteristics of this sample are identical with the long-lived activity from the other bombardments. The sample has been studied on a "magnetic" counter. No positron emission, but only a single peak of conversion electrons has been observed. Chemical separation showed no evidence for any platinum daughter of half-life greater than about thirty seconds. Allocation to mass 195 is consistent with the yields and the half-life is consistent with expectations for a gold isotope of this mass number.

39.5-hour gold.—Previously unreported, this activity is formed in high yields in Pt+d and Ir+α bombardments. Chemical separations give no evidence of a platinum daughter activity of half-life greater than a few minutes.

15.8-hour gold.—Evidence for a gold isotope of half-life 16±1 hours, parent of the 4.3-day Pt^{193} was obtained in chemical separations from gold fractions of Pt+d and Ir+α bombardments and decay of the gold fraction in the latter showed an activity of 15.8-hours half-life. A half-life for Au^{193} longer than 16 hours and of the order of days might have been expected from consideration of the stability of isotopes of elements of odd Z in this region, but since the allocation of Pt^{193} seems reliable, the gold parent has been allocated similarly. No activity which might be a longer lived isomer has been yet detected in the decay of the gold fractions from either Pt+d or Ir+α bombardments.

TABLE I.

Element	Probable mass number	Half-Life	Energy of radiations (Mev) Particles	γ-Rays	Probable mode of formation
$_{78}$Pt	191	3.00±0.02 d	0.5	x-rays	Ir-d-$2n$
				0.57	Au (~1 day) decay
				1.8	Pt-n-$2n$
	193	4.33±0.03 d	0.10	x-rays	Ir-d-$2n$, Ir-α-p-$2n$
				1.7	Au (16 hour) decay
				~0.17	Pt-d-p
					Pt-n-γ, Pt-n-$2n$
$_{79}$Au	191	~1 d	?	?	Ir-α-$4n$
					Pt-d-$3n$
	192	4.7±0.1 h	~0.3	x-rays	Ir-α-$3n$
			>2	~3	Pt-d-$2n$
	193	15.8±0.3 h	<0.3	x-rays	Ir-α-$2n$, Ir-α-$4n$
					Pt-d-$3n$
	194	39.5±0.5 h	0.31	x-rays	Ir-α-$3n$
			~1.8	0.38	Pt-d-$2n$, Pt-d-$3n$
				1.9	
	195	195±5 d	0.08	x-rays	Ir-α-$2n$
				1.7	Pt-d-$2n$, Pt-d-$3n$
				0.17	Pt-d-n
	196	5.55±0.05 d	0.34	x-rays	Pt-d-$2n$, Pt-d-n
				0.41	Au-n-$2n$
				1.7	
	196	14±0.5 h	?	x-rays	Au-n-$2n$

4.7-hour gold.—Previously unreported, this activity with a characteristic very hard gamma-ray has been observed in chemically separated gold fractions from both Ir+α and Pt+d reactions. Provisional assignment to mass 192 has been made on the basis of reaction yields, and absence of any daughter activity.

~1-day gold.—The 3.0-day platinum provisionally assigned to mass 191 grows in the chemically separated gold fraction from a parent of ~1-day half-life in both Ir+α and Pt+d bombardments. The yield is low in both cases, and the isotope has not been directly observed.

A search is being made for shorter lived activities, and a full report on isotopes of platinum and gold will be published subsequently.

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