Radioactive Isotopes of Re, Os, and Ir

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Two new radioactive isotopes have been found, Os^{185} produced by a Re$(d,2n)$ reaction and Ir^{190} produced by Ir$(n,2n)$ and by Os(d,n) reactions. The following characteristic values have been assigned to the isotopes in Re, Os, and Ir:

ISOTOPE	HALF-LIFE	β-PARTICLE	γ-RAYS
Re^{186}	92.8 hours	1.07 Mev	No γ-rays
Re^{188}	18.9 hours	2.05 Mev	
Os^{185}	94.7 days		
Os^{191}	31.9 hours	0.95 Mev	1.17 Mev
Ir^{190}	10.7 days	0.091 Mev*	0.25 Mev
Ir^{192}	75 days	0.59 Mev	0.53 Mev
Ir^{194}	19.0 hours	2.07 Mev	0.38 Mev and 1.65 Mev

* Probably Internal Conversion Electrons

The 17-day osmium activity has not been found. Chemical separations were carried out on the rhenium and osmium bombardments.

INTRODUCTION

AN activity in rhenium was first found,[1] when bombarding rhenium with neutrons from a Ra+Be source, to be of about 20 hours. With another Ra+Be source of neutrons there was found[2] a 20-hour and an 85-hour period. With fast neutrons[3] only an 18-hour period was found. The isotopes were placed and β-particle energy values were given after a deuteron bombardment of rhenium. The values assigned[4] were a 1.2-Mev β-particle for Re^{186} (90 hours) and a 2.5-Mev for Re^{188} (16-hour). The assignment of these isotopes was confirmed[5] by producing Re^{186} by a W$(d,2n)$ reaction.

The radioactive isotopes in osmium have been reported as a 40-hour period[4] produced by slow neutrons and as 29.8-hour and 10-day periods[6] produced by neutron bombardment. Also reported[7] have been a 32-hour period with a β-particle of 1.5 Mev and a 17-day period with a β-particle of 0.35 Mev.

Two periods are known to be produced when iridium is irradiated with neutrons, a 19-hour[8] period and a 60-day period.[9] The β-particle energy of the shorter period has been measured[10] and found to be 2.1 Mev. The periods were later reported[11] as 19.5-hour and a 68-day periods. These have been placed[12] using mass spectrographic technique at Ir^{194} and Ir^{192}, respectively.

The investigation of the isotopes of rhenium, osmium and iridium was undertaken to clarify the existing disagreements and to give radioactive constants for the isotopes.

Re^{186} AND Re^{188}

Hilger Re metal (Lab. no. 9310) was activated by 10-Mev deuterons. To the active sample was added 50 mg of Os metal carrier, which was then placed in an all-glass distilling apparatus. Concentrated HNO_3 (30 cc) was added to dissolve the metals and the solution then boiled and brought nearly to dryness. More concentrated HNO_3 (20 cc) was then added and solution distilled until only a small amount of liquid (7 cc) remained in the distilling flask. The distillate, OsO_4, was collected in alkaline $(NH_4)_2S_x$ which precipitated the Os as OsS_4. The OsS_4 was filtered and measured for radioactivity. The Re

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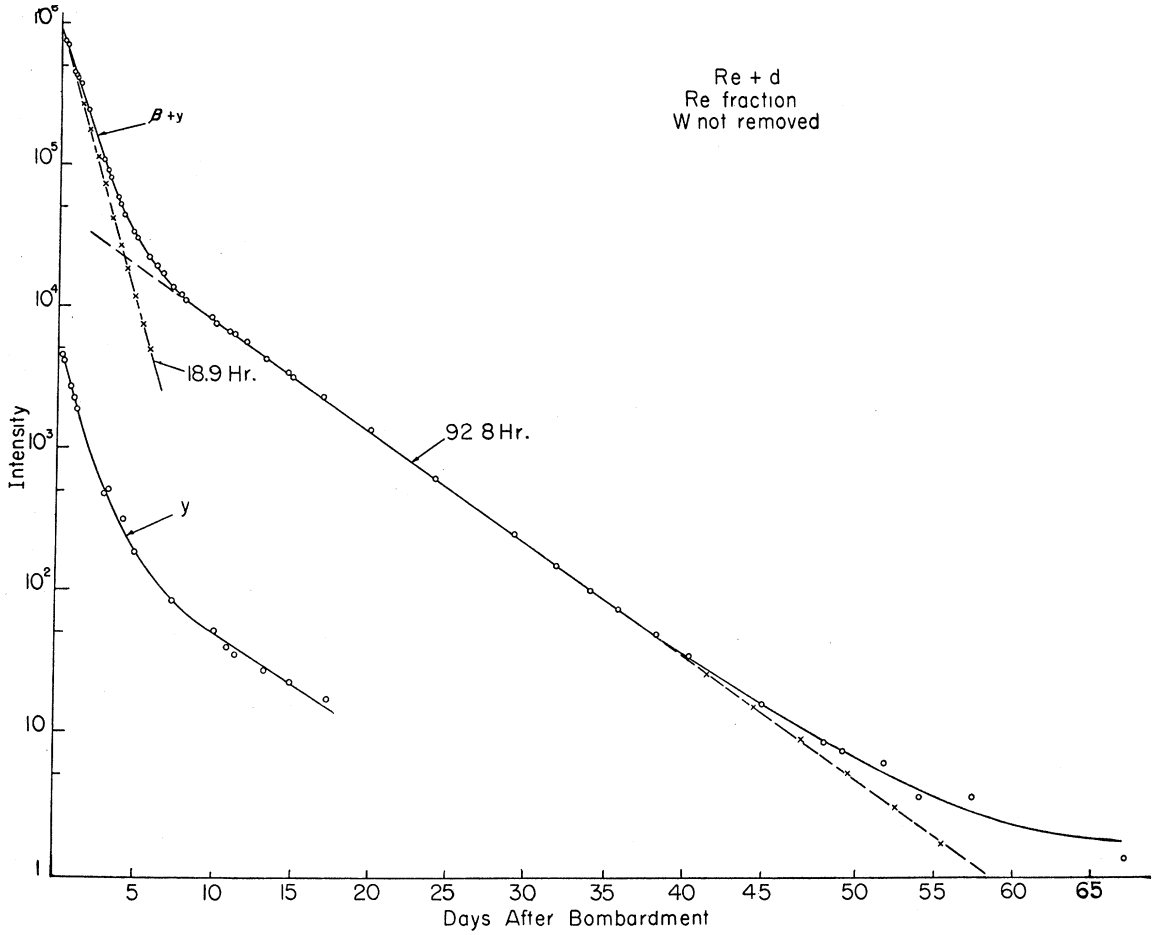

FIG. 1. Decay of Re^{186} and Re^{188}. The intensities of the γ-rays are shown as ten times their actual values.

fraction was heated with a small amount (1.0 cc) of H_2SO_4 until SO_3 fumes appeared. The solution was then cooled and diluted with H_2O. The rhenium was precipitated as the sulfide, filtered and measured for radioactivity. It was supposed that any tungsten would remain in the rhenium fraction.

The decay curve of the rhenium fraction is illustrated in Fig. 1. The half-lives were found to be 18.9±0.2-hours and 92.8±0.2-hours. These values are assigned to Re^{188} and Re^{186}, respectively, in accordance with previous workers.[4,5] The large change in intensity over which the activity was followed made possible this claim of 0.2 percent error.

Aluminum absorptions of Re^{186} and Re^{188} are shown in Fig. 2. The former gives a β-end point of 0.442 g/cm² of aluminum or equivalent to 1.07 Mev according to $R=0.526E-0.094$.[13] Re^{188} gives a β-end point of 0.995 g/cm² of aluminum, equivalent to 2.05 Mev. There are no γ-rays associated with Re^{186} and the number of γ-rays associated with Re^{188} are less than one per four β-particles.

The relative saturation intensities are 6800: 18000 for Re^{188}:Re^{186}. The previously reported $Re(d,\alpha)$ reaction producing W^{185} was expected but not found. Assuming either W^{185} or Re^{184} (produced by stray neutrons) were present in the tail end of Fig. 1, the relative saturation intensity would be the order of unity.

Os^{191}

In order to investigate the decay of osmium, a 0.5 gram sample of osmium metal was irradiated

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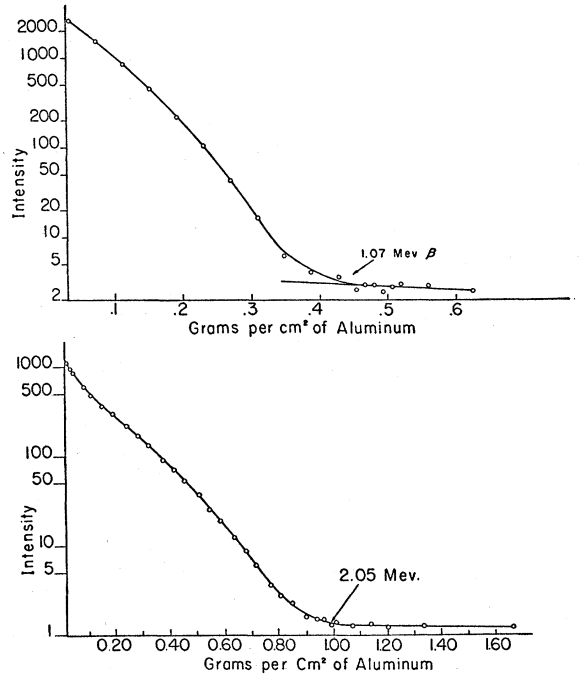

FIG. 2. Absorption in aluminum of β-rays from Re^{186} and Re^{188}.

with slow neutrons produced by Be+p(5 Mev) for 17 hours. Figure 3 shows the decay of this sample.

The 31.9-hour period is seen as the principal activity present. The previously reported 17-day period has not been found even though long

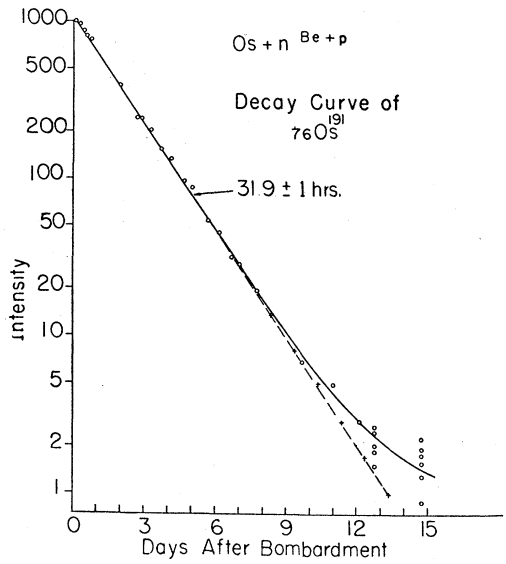

FIG. 3. Decay of Os^{191} produced by slow neutrons.

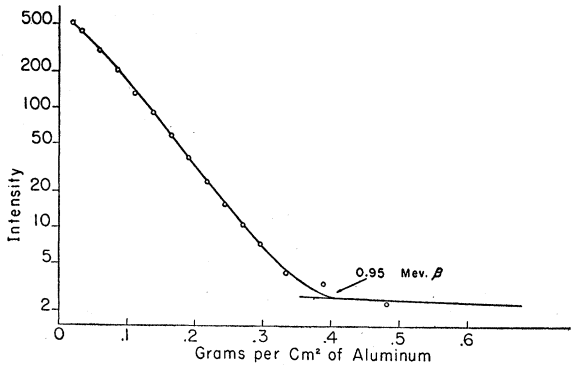

FIG. 4. Absorption in aluminum of β-rays from Os^{191}.

bombardments were made. Assuming the 17-day period present in the tail end of Fig. 3 the ratio of the saturation intensities found would be of the order of 250:1.

Figure 4 shows an aluminum absorption during the 31.9-hour period of the β-rays from an osmium fraction of an Os+d bombardment. The β-end point of 0.400 g/cm² of aluminum, equivalent to 0.95 Mev, was found. A lead absorption revealed a γ-ray of half-thickness of 0.40 inch or of 1.17 Mev.

A weak activity of about 30-hour half-life has been obtained by bombarding iridium with deuterons, presumably caused by an Ir(d,α) reaction leading to Os^{191}.

Os^{185}

A new period has been found in the osmium fraction after a deuteron bombardment of Re. The chemical separations were carried out as previously described. The decay of this isotope is shown in Fig. 5 and is seen to have a half-life

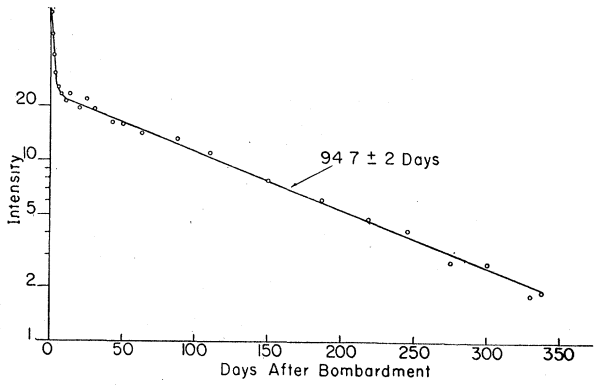

FIG. 5. Decay of Os fraction of Re+d; Os^{185}.

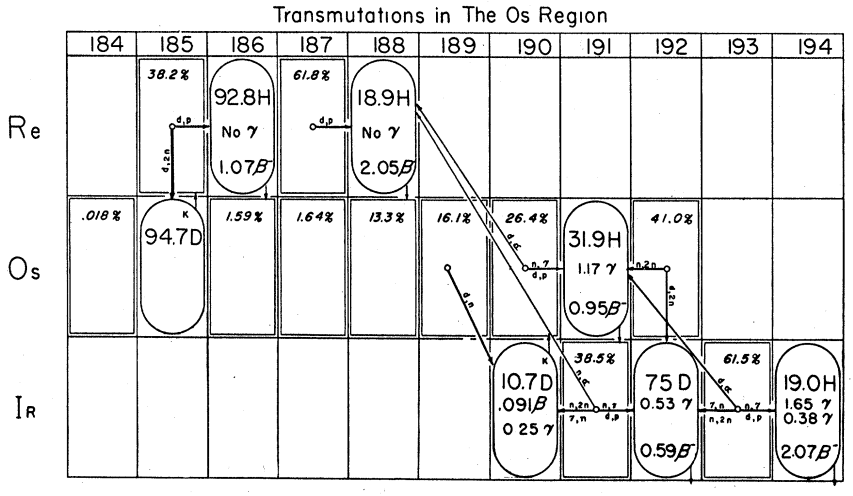

FIG. 6. Summary chart of Re, Os, and Ir isotopes giving the radioactive constants discussed in this paper.

of 94.7±2.0 days. The isotope is predominately γ-ray emitting and has been tentatively placed at Os^{185}. It is believed that Os^{185} decays by K-electron capture. The previously reported[14] 30-hour isomer of Os^{185}, produced by $Re(d,n)$ was not confirmed when very pure rhenium was used.

In Fig. 6 is shown a chart which summarizes the reactions and values given in this paper.

Ir^{190}

A new period has been found in iridium. It has been made by irradiating iridium with fast neutrons and has been found in the iridium chemical fraction after bombarding osmium with deuterons. The decay of the iridium activity induced by neutrons from Li+d is shown in Fig. 7. The half-lives are seen to be approximately 10.7 days and 75 days.

Since the 10.7-day period has been made by fast neutrons on iridium and by $Os(d,n)$ and has not been found with slow neutrons or with deuterons on iridium, the activity is therefore ascribed to Ir^{190}. From the various bombardments the half-life of 10.7±0.3 days is associated with this period.

Associated with Ir^{190} is an internal conversion

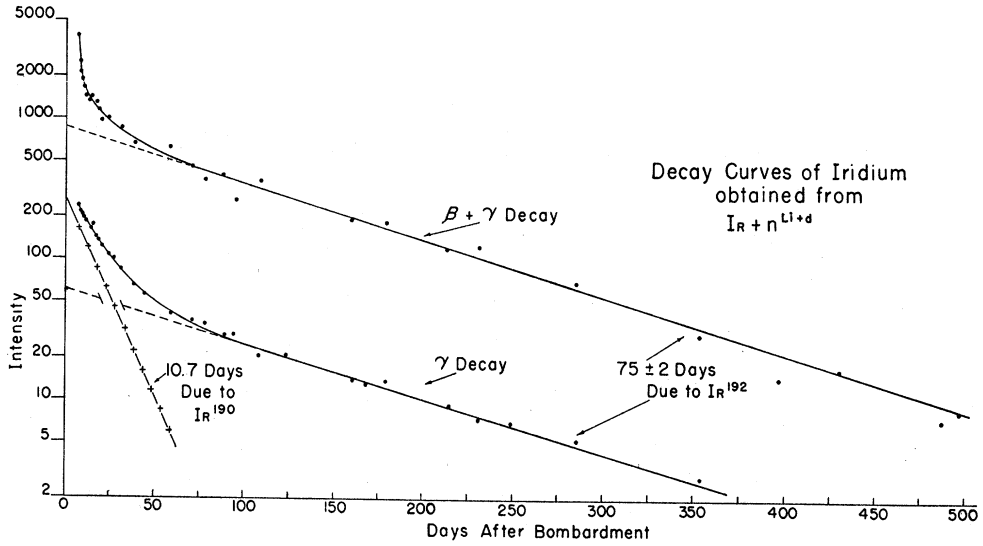

FIG. 7. Decay of Ir^{190} and Ir^{192}.

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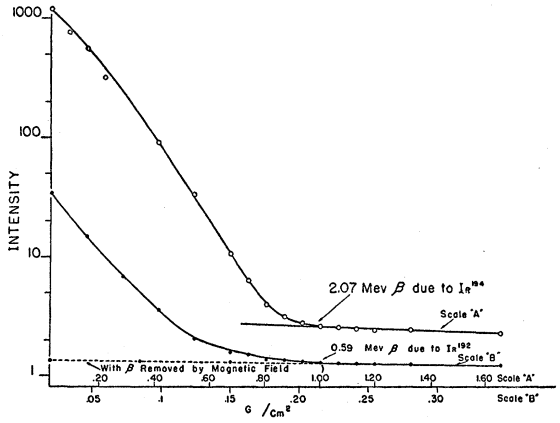

FIG. 8. Absorption in aluminum of β-rays of Ir^{192} and Ir^{194}.

electron or very soft β-particle and a γ-ray. The electron has an end point of 0.0110 g/cm² of aluminum or an energy of 91 Kev. The γ-ray when absorbed in lead, has a half-thickness of 0.039 inch or an energy of 0.25 Mev. X-rays have also been found to be associated with this period, suggesting K-electron capture.

Ir^{192} AND Ir^{194}

The 19.5-hour and 68-day period[11] in iridium have been placed[12] at Ir^{194} and Ir^{192}, respectively. Half-life measurements of these isotopes have given values of 19.0±0.2-hours for Ir^{194} and of 75±3-days for Ir^{192} agreeing with the previously reported periods.

The β-end point of Ir^{192}, as shown in Fig. 8 has been found to be 0.216±0.007 g/cm² of aluminum, equivalent to 0.59±0.01 Mev. The Ir^{194} β-end point of 1.00±0.02 g/cm² of aluminum, equivalent to 2.07±0.03 Mev, which agrees well with the previously reported[15] value of 0.970±0.030 g/cm².

The γ-rays of Ir^{194} and Ir^{192} were previously reported[16] as 1.35 Mev and 0.63 Mev, respectively. The values of 1.65 Mev and 0.38 Mev for Ir^{194} and 0.52 Mev for Ir^{192} have been obtained.

The procedure devised to study the γ-radiation was as follows. A number of lead and tin absorption curves were made at intervals after an Ir+d bombardment and the intensities of the γ-rays, when extrapolated back to zero thickness of lead (I_0), were plotted as ordinates against time after bombardment. An absorption curve illustrating how these values of I_0 were obtained is shown in Fig. 9. This absorption curve shows a γ-ray of half-thickness in lead of 0.500 inch, equivalent to 1.65 Mev, and a γ-ray of half-

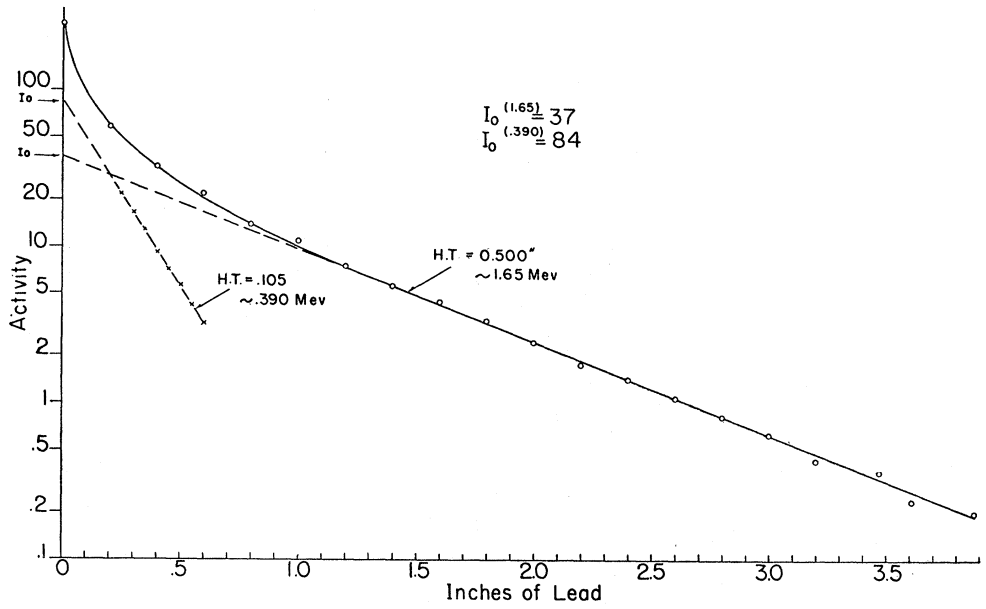

FIG. 9. Absorption in lead of γ-rays from Ir+d bombardment. The values of I_0 for this absorption curve as shown.

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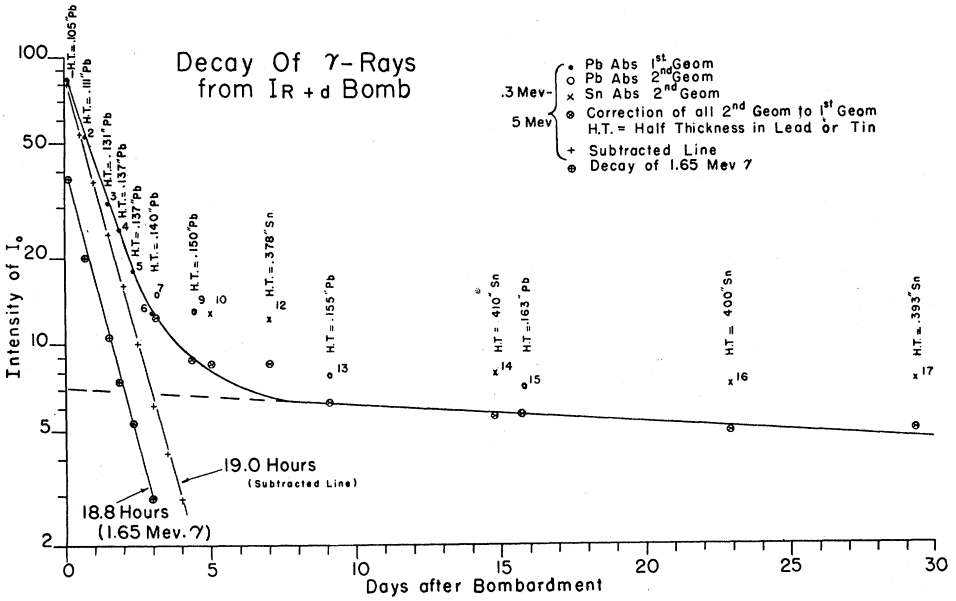

FIG. 10. Decay curve of I_0. The values of the half-thicknesses in tin and lead are shown for each absorption.

thickness in lead of 0.105 inch, equivalent to 0.39 Mev. The decrease in intensity of these zero thickness values with time is shown in Fig. 10. The I_0 of the γ-ray of 1.65 Mev is seen to decay on an 18.8-hour half-life.

The decay curve of the other I_0 is seen to have two half-life components, a 19-hour period and a 75-day period. It was found that the half-thickness value in lead of the curve associated with this I_0 increased with each absorption after the first, varying in half-thickness value from 0.105 inch for the first absorption curve to a value of 0.163 inch when the 19-hour component of the decay curve was no longer present. In order to explain the fact that there are different energies for each absorption, it is necessary to assume that there are two γ-rays, one associated with each period, which cannot be resolved by lead absorption technique. Using the half-thickness in lead value of 0.163 inch equivalent to 0.52 Mev, as that of the energy of the γ-ray associated with Ir^{192} (75-day), it has been calculated that the half-thickness of the γ-ray associated with Ir^{194} (19-hour) is 0.102 inch of lead, equivalent to 0.38 Mev.

POSSIBLE ENERGY LEVELS FOR Ir^{194}

Ir^{194} has been found to have a β-particle of 2.07 Mev and γ-rays of 1.65 Mev and 0.38 Mev. The two γ-rays are of approximately the same intensity and there are in the neighborhood of four β-particles for each group of the two γ-rays. This suggests that there may be two alternate methods of decay. First by simple emission of a 2.07-Mev β-particle, and second by consecutive emission of the two γ-rays, and then by emitting a low energy β-particle (about 0.03 Mev). This low energy β-particle has not as yet been found. On the basis of the above proposed scheme of decay the first procedure takes place 80 percent of the time.

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