Osmium-180

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Osmium (76Os) has seven naturally occurring isotopes, five of which are stable: 187Os, 188Os, 189Os, 190Os, and (most abundant) 192Os. The other natural isotopes, 184Os, and 186Os, have extremely long half-life (1.12×1013 years and 2×1015 years, respectively) and for practical purposes can be considered to be stable as well. 187Os is the daughter of 187Re (half-life 4.56×1010 years) and is most often measured in an 187Os/188Os ratio. This ratio, as well as the 187Re/188Os ratio, have been used extensively in dating terrestrial as well as meteoric rocks. It has also been used to measure the intensity of continental weathering over geologic time and to fix minimum ages for stabilization of the mantle roots of continental cratons. However, the most notable application of Os in dating has been in conjunction with iridium, to analyze the layer of shocked quartz along the Cretaceous–Paleogene boundary that marks the extinction of the dinosaurs 66 million years ago. There are also 30 artificial radioisotopes, the longest-lived of which is 194Os with a half-life of six years; all others have half-lives under 94 days. There are also nine known nuclear isomers, the longest-lived of which is 191mOs with a half-life of 13.10 hours. All isotopes and nuclear isomers of osmium are either radioactive or observationally stable, meaning that they are predicted to be radioactive but no actual decay has been observed.

nuclear isomers radioisotopes cretaceous–paleogene

1. Uses of Osmium Isotopes

The isotopic ratio of osmium-187 and osmium-188 (^{187}Os/^{188}Os) can be used as a window into geochemical changes throughout the ocean's history.[1] The average marine ^{187}Os/^{188}Os ratio in oceans is 1.06.[1] This value represents a balance of the continental derived riverine inputs of Os with a ^{187}Os/^{188}Os ratio of ~1.3, and the mantle/extraterrestrial inputs with a ^{187}Os/^{188}Os ratio of ~0.13.[1] Being a descendent of ^{187}Re, ^{187}Os can be radiogenically formed by beta decay.[2] This decay has actually pushed the ^{187}Os/^{188}Os ratio of the Bulk silicate earth (Earth minus the core) by 33%.[3] This is what drives the difference in the ^{187}Os/^{188}Os ratio we see between continental materials and mantle material. Crustal rocks have a much higher level of Re, which slowly degrades into ^{187}Os driving up the ratio.[2] Within the mantle however, the uneven response of Re and Os results in these mantle, and melted materials being depleted in Re, and do not allow for them to accumulate ^{187}Os like the continental material.[2] The input of both materials in the marine environment results in the observed ^{187}Os/^{188}Os of the oceans and has fluctuated greatly over the history of our planet. These changes in the isotopic values of marine Os can be observed in the marine sediment that is deposited, and eventually lithified in that time period.[4] This allows for researchers to make estimates on weathering fluxes, identifying flood basalt volcanism, and impact events that may have caused some of our largest mass extinctions. The marine sediment Os isotope record has been used to identify and corroborate the impact of the K-T boundary for example.[5] The impact of this ~10 km asteroid massively altered the $^{187}Os/^{188}Os$ signature of marine sediments at that time. With the average extraterrestrial $^{187}Os/^{188}Os$ of ~0.13 and the huge amount of Os this impact contributed (equivalent to 600,000 years of present-day riverine inputs) lowered the global marine $^{187}Os/^{188}Os$ value of ~0.45 to ~0.2.[1]

Os isotope ratios may also be used as a signal of anthropogenic impact.[6] The same $^{187}Os/^{188}Os$ ratios that are common in geological settings may be used to gauge the addition of anthropogenic Os through things like catalytic converters.[6] While catalytic converters have been shown to drastically reduce the emission of NO_x and CO_2, they are introducing platinum group elements (PGE) such as Os, to the environment.[6] Other sources of anthropogenic Os include combustion of fossil fuels, smelting chromium ore, and smelting of some sulfide ores. In one study, the effect of automobile exhaust on the marine Os system was evaluated. Automobile exhaust $^{187}Os/^{188}Os$ has been recorded to be ~0.2 (similar to extraterrestrial and mantle derived inputs) which is heavily depleted (3, 7). The effect of anthropogenic Os can be seen best by comparing aquatic Os ratios and local sediments or deeper waters. Impacted surface waters tend to have depleted values compared to deep ocean and sediments beyond the limit of what is expected from cosmic inputs.[6] This increase in effect is thought to be due to the introduction of anthropogenic airborne Os into precipitation.

The long half-life of ^{184}Os with respect to alpha decay to ^{180}W has been proposed as a radiometric dating method for osmium-rich rocks or for differentiation of a planetary core.[7]

2. List of Isotopes

Nuclide [8]	*Z*	*N*	Isotopic mass (u) [9][10]	Half-life [11]	Decay mode [12]	Daughter isotope [13][14]	Spin and parity [15][16]	Physics:Natural abundance (mole fraction)	
	Excitation energy							Normal proportion	Range of variation
^{161}Os	76	85		0.64(6) ms	α	^{157}W			
^{162}Os	76	86	161.98443(54)#	1.87(18) ms	α	^{158}W	0+		
^{163}Os	76	87	162.98269(43)#	5.5(6) ms	α	^{159}W	7/2−#		
					$β^+$, p (rare)	^{162}W			
					$β^+$ (rare)	^{163}Re			
^{164}Os	76	88	163.97804(22)	21(1) ms	α (98%)	^{160}W	0+		
					$β^+$ (2%)	^{164}Re			

^{165}Os	76	89	164.97676(22)#	71(3) ms	α (60%)	^{161}W	(7/2−)
					β+ (40%)	^{165}Re	
^{166}Os	76	90	165.972691(20)	216(9) ms	α (72%)	^{162}W	0+
					β+ (28%)	^{166}Re	
^{167}Os	76	91	166.97155(8)	810(60) ms	α (67%)	^{163}W	3/2−#
					β+ (33%)	^{167}Re	
^{168}Os	76	92	167.967804(13)	2.06(6) s	β+ (51%)	^{168}Re	0+
					α (49%)	^{164}W	
^{169}Os	76	93	168.967019(27)	3.40(9) s	β+ (89%)	^{169}Re	3/2−#
					α (11%)	^{165}W	
^{170}Os	76	94	169.963577(12)	7.46(23) s	β+ (91.4%)	^{170}Re	0+
					α (8.6%)	^{166}W	
^{171}Os	76	95	170.963185(20)	8.3(2) s	β+ (98.3%)	^{171}Re	(5/2−)
					α (1.7%)	^{167}W	
^{172}Os	76	96	171.960023(16)	19.2(5) s	β+ (98.9%)	^{172}Re	0+
					α (1.1%)	^{168}W	
^{173}Os	76	97	172.959808(16)	22.4(9) s	β+ (99.6%)	^{173}Re	(5/2−)
					α (.4%)	^{169}W	
^{174}Os	76	98	173.957062(12)	44(4) s	β+ (99.97%)	^{174}Re	0+
					α (.024%)	^{170}W	
^{175}Os	76	99	174.956946(15)	1.4(1) min	β+	^{175}Re	(5/2−)
^{176}Os	76	100	175.95481(3)	3.6(5) min	β+	^{176}Re	0+

^{177}Os	76	101	176.954965(17)	3.0(2) min	β^+	^{177}Re	1/2−	
^{178}Os	76	102	177.953251(18)	5.0(4) min	β^+	^{178}Re	0+	
^{179}Os	76	103	178.953816(19)	6.5(3) min	β^+	^{179}Re	(1/2−)	
^{180}Os	76	104	179.952379(22)	21.5(4) min	β^+	^{180}Re	0+	
^{181}Os	76	105	180.95324(3)	105(3) min	β^+	^{181}Re	1/2−	
^{181m1}Os	48.9(2) keV			2.7(1) min	β^+	^{181}Re	(7/2)−	
^{181m2}Os	156.5(7) keV			316(18) ns			(9/2)+	
^{182}Os	76	106	181.952110(23)	22.10(25) h	EC	^{182}Re	0+	
^{183}Os	76	107	182.95313(5)	13.0(5) h	β^+	^{183}Re	9/2+	
^{183m}Os	170.71(5) keV			9.9(3) h	β^+ (85%)	^{183}Re	1/2−	
					IT (15%)	^{183}Os		
^{184}Os	76	108	183.9524891(14)	**1.12(23)×10^{13} y**[7]	α[17]	***^{180}W***	0+	2(1)×10^{-4}
^{185}Os	76	109	184.9540423(14)	93.6(5) d	EC	**^{185}Re**	1/2−	
^{185m1}Os	102.3(7) keV			3.0(4) μs			(7/2−)#	
^{185m2}Os	275.7(8) keV			0.78(5) μs			(11/2+)	
^{186}Os[18]	76	110	185.9538382(15)	**2.0(11)×10^{15} y**	α	**^{182}W**	0+	0.0159(3)
^{187}Os[19]	76	111	186.9557505(15)	**Observationally Stable**[20]			1/2−	0.0196(2)
^{188}Os[19]	76	112	187.9558382(15)	**Observationally Stable**[21]			0+	0.1324(8)
^{189}Os	76	113	188.9581475(16)	**Observationally Stable**[22]			3/2−	0.1615(5)
^{189m}Os	30.812(15) keV			5.81(6) h	IT	**^{189}Os**	9/2−	
^{190}Os	76	114	189.9584470(16)	**Observationally Stable**[23]			0+	0.2626(2)
^{190m}Os	1705.4(2) keV			9.9(1) min	IT	**^{190}Os**	(10)−	
^{191}Os	76	115	190.9609297(16)	15.4(1) d	β^-	**^{191}Ir**	9/2−	
^{191m}Os	74.382(3) keV			13.10(5) h	IT	^{191}Os	3/2−	
^{192}Os	76	116	191.9614807(27)	**Observationally Stable**[24]			0+	0.4078(19)

^{192m}Os	2015.40(11) keV			5.9(1) s	IT (87%)	**^{192}Os**	(10−)
					β⁻ (13%)	^{192}Ir	
^{193}Os	76	117	192.9641516(27)	30.11(1) h	β⁻	**^{193}Ir**	3/2−
^{194}Os	76	118	193.9651821(28)	6.0(2) y	β⁻	^{194}Ir	0+
^{195}Os	76	119	194.96813(54)	6.5 min	β⁻	^{195}Ir	3/2−#
^{196}Os	76	120	195.96964(4)	34.9(2) min	β⁻	^{196}Ir	0+
^{197}Os	76	121		2.8(6) min			

1. ↑ ^{m}Os – Excited nuclear isomer.
2. ↑ ( ) – Uncertainty (1σ) is given in concise form in parentheses after the corresponding last digits.
3. ↑ # – Atomic mass marked #: value and uncertainty derived not from purely experimental data, but at least partly from trends from the Mass Surface (TMS).
4. ↑ **Bold half-life** – nearly stable, half-life longer than age of universe.
5. ↑ Modes of decay:

EC:	Electron capture
IT:	Isomeric transition
p:	Proton emission

6. ↑ ***Bold italics symbol*** as daughter – Daughter product is nearly stable.
7. ↑ **Bold symbol** as daughter – Daughter product is stable.
8. ↑ ( ) spin value – Indicates spin with weak assignment arguments.
9. ↑ # – Values marked # are not purely derived from experimental data, but at least partly from trends of neighboring nuclides (TNN).
10. ↑ Theorized to also undergo $\beta^+\beta^+$ decay to **^{184}W**
11. ↑ primordial radionuclide
12. ↑ [12.0] [12.1] Used in rhenium-osmium dating
13. ↑ Believed to undergo α decay to **^{183}W**
14. ↑ Believed to undergo α decay to **^{184}W**
15. ↑ Believed to undergo α decay to ^{185}W
16. ↑ Believed to undergo α decay to **^{186}W**
17. ↑ Believed to undergo α decay to ^{188}W or $\beta^-\beta^-$ decay to **^{192}Pt** with a half-life over 9.8×10^{12} years

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7. error
8. mOs – Excited nuclear isomer.
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12. Modes of decay: EC: Electron capture IT: Isomeric transition p: Proton emission
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22. Believed to undergo α decay to 185W
23. Believed to undergo α decay to 186W
24. Believed to undergo α decay to 188W or β−β− decay to 192Pt with a half-life over 9.8×1012 years