Isotopes of caesium

Caesium ($_{55}$Cs) has 40 known isotopes, making it, along with barium and mercury, one of the elements with the most isotopes.[3] The atomic masses of these isotopes range from 112 to 151. Only one isotope, ^{133}Cs, is stable. The longest-lived radioisotopes are ^{135}Cs with a half-life of 2.3 million years, ^{137}Cs with a half-life of 30.1671 years and ^{134}Cs with a half-life of 2.0652 years. All other isotopes have half-lives less than 2 weeks, most under an hour.

Beginning in 1945 with the commencement of nuclear testing, caesium isotopes were released into the atmosphere where caesium is absorbed readily into solution and is returned to the surface of the earth as a component of radioactive fallout. Once caesium enters the ground water, it is deposited on soil surfaces and removed from the landscape primarily by particle transport. As a result, the input function of these isotopes can be estimated as a function of time.

Main isotopes of caesium ($_{55}$Cs)

Isotope			Decay	
	abun-dance	half-life ($t_{1/2}$)	mode	pro-duct
^{131}Cs	syn	9.7 d	ε	^{131}Xe
^{133}Cs	100%	stable		
^{134}Cs	syn	2.0648 y	ε	^{134}Xe
			β⁻	^{134}Ba
^{135}Cs	trace	2.3×10^{6} y	β⁻	^{135}Ba
^{137}Cs	syn	30.17 y[1]	β⁻	^{137}Ba

Standard atomic weight $A_{r, standard}$(Cs)	132.905 451 96(6)[2]

Contents

List of isotopes

Nuclide [n 1]	Z	N	Isotopic mass (Da) [n 2][n 3]	Half-life	Decay mode [n 4]	Daughter isotope [n 5][n 6]	Spin and parity [n 7][n 8]	Natural abundance (mole fraction)	
	Excitation energy[n 8]							Normal proportion	Range of variation
^{112}Cs	55	57	111.95030(33)#	500(100) μs	p	^{111}Xe	1+#		
					α	^{108}I			
^{113}Cs	55	58	112.94449(11)	16.7(7) μs	p (99.97%)	^{112}Xe	5/2+#		
					β$^+$ (.03%)	^{113}Xe			
^{114}Cs	55	59	113.94145(33)#	0.57(2) s	β$^+$ (91.09%)	^{114}Xe	(1+)		
					β$^+$, p (8.69%)	^{113}I			
					β$^+$, α (.19%)	^{110}Te			
					α (.018%)	^{110}I			
^{115}Cs	55	60	114.93591(32)#	1.4(8) s	β$^+$ (99.93%)	^{115}Xe	9/2+#		
					β$^+$, p (.07%)	^{114}I			
^{116}Cs	55	61	115.93337(11)#	0.70(4) s	β$^+$ (99.67%)	^{116}Xe	(1+)		
					β$^+$, p (.279%)	^{115}I			
					β$^+$, α (.049%)	^{112}Te			
^{116m}Cs	100(60)# keV			3.85(13) s	β$^+$ (99.48%)	^{116}Xe	4+, 5, 6		
					β$^+$, p (.51%)	^{115}I			
					β$^+$, α (.008%)	^{112}Te			
^{117}Cs	55	62	116.92867(7)	8.4(6) s	β$^+$	^{117}Xe	(9/2+)#		
^{117m}Cs	150(80)# keV			6.5(4) s	β$^+$	^{117}Xe	3/2+#		
^{118}Cs	55	63	117.926559(14)	14(2) s	β$^+$ (99.95%)	^{118}Xe	2		
					β$^+$, p (.042%)	^{117}I			
					β$^+$, α (.0024%)	^{114}Te			
^{118m}Cs	100(60)# keV			17(3) s	β$^+$ (99.95%)	^{118}Xe	(7−)		
					β$^+$, p (.042%)	^{117}I			
					β$^+$, α (.0024%)	^{114}Te			
^{119}Cs	55	64	118.922377(15)	43.0(2) s	β$^+$	^{119}Xe	9/2+		
					β$^+$, α (2×10^{-6}%)	^{115}Te			
^{119m}Cs	50(30)# keV			30.4(1) s	β$^+$	^{119}Xe	3/2(+)		
^{120}Cs	55	65	119.920677(11)	61.2(18) s	β$^+$	^{120}Xe	2(−#)		
					β$^+$, α (2×10^{-5}%)	^{116}Te			
					β$^+$, p (7×10^{-6}%)	^{119}I			
^{120m}Cs	100(60)# keV			57(6) s	β$^+$	^{120}Xe	(7−)		
					β$^+$, α (2×10^{-5}%)	^{116}Te			
					β$^+$, p (7×10^{-6}%)	^{119}I			
^{121}Cs	55	66	120.917229(15)	155(4) s	β$^+$	^{121}Xe	3/2(+)		
^{121m}Cs	68.5(3) keV			122(3) s	β$^+$ (83%)	^{121}Xe	9/2(+)		
					IT (17%)	^{121}Cs			
^{122}Cs	55	67	121.91611(3)	21.18(19) s	β$^+$	^{122}Xe	1+		
					β$^+$, α (2×10^{-7}%)	^{118}Te			
^{122m1}Cs	45.8 keV			>1 μs			(3)+		
^{122m2}Cs	140(30) keV			3.70(11) min	β$^+$	^{122}Xe	8−		
^{122m3}Cs	127.0(5) keV			360(20) ms			(5)−		
^{123}Cs	55	68	122.912996(13)	5.88(3) min	β$^+$	^{123}Xe	1/2+		
^{123m1}Cs	156.27(5) keV			1.64(12) s	IT	^{123}Cs	(11/2)−		
^{123m2}Cs	231.63+X keV			114(5) ns			(9/2+)		
^{124}Cs	55	69	123.912258(9)	30.9(4) s	β$^+$	***^{124}Xe***	1+		
^{124m}Cs	462.55(17) keV			6.3(2) s	IT	^{124}Cs	(7)+		

^{125}Cs	55	70	124.909728(8)	46.7(1) min	β^+	^{125}Xe	1/2(+)		
^{125m}Cs	266.6(11) keV			900(30) ms			(11/2−)		
^{126}Cs	55	71	125.909452(13)	1.64(2) min	β^+	**^{126}Xe**	1+		
^{126m1}Cs	273.0(7) keV			>1 μs					
^{126m2}Cs	596.1(11) keV			171(14) μs					
^{127}Cs	55	72	126.907418(6)	6.25(10) h	β^+	^{127}Xe	1/2+		
^{127m}Cs	452.23(21) keV			55(3) μs			(11/2)−		
^{128}Cs	55	73	127.907749(6)	3.640(14) min	β^+	**^{128}Xe**	1+		
^{129}Cs	55	74	128.906064(5)	32.06(6) h	β^+	**^{129}Xe**	1/2+		
^{130}Cs	55	75	129.906709(9)	29.21(4) min	β^+ (98.4%)	**^{130}Xe**	1+		
					β^- (1.6%)	***^{130}Ba***			
^{130m}Cs	163.25(11) keV			3.46(6) min	IT (99.83%)	^{130}Cs	5−		
					β^+ (.16%)	**^{130}Xe**			
^{131}Cs	55	76	130.905464(5)	9.689(16) d	EC	**^{131}Xe**	5/2+		
^{132}Cs	55	77	131.9064343(20)	6.480(6) d	β^+ (98.13%)	**^{132}Xe**	2+		
					β^- (1.87%)	**^{132}Ba**			
^{133}Cs[n 9][n 10]	55	78	132.905451933(24)	**Stable**			7/2+	1.0000	
^{134}Cs[n 10]	55	79	133.906718475(28)	2.0652(4) y	β^-	**^{134}Ba**	4+		
					EC (3×10^{-4}%)	**^{134}Xe**			
^{134m}Cs	138.7441(26) keV			2.912(2) h	IT	^{134}Cs	8−		
^{135}Cs[n 10]	55	80	134.9059770(11)	2.3 x10^6 y	β^-	**^{135}Ba**	7/2+		
^{135m}Cs	1632.9(15) keV			53(2) min	IT	^{135}Cs	19/2−		
^{136}Cs	55	81	135.9073116(20)	13.16(3) d	β^-	**^{136}Ba**	5+		
^{136m}Cs	518(5) keV			19(2) s	β^-	**^{136}Ba**	8−		
					IT	^{136}Cs			
^{137}Cs[n 10]	55	82	136.9070895(5)	30.1671(13) y	β^- (95%)	^{137m}Ba	7/2+		
					β^- (5%)	**^{137}Ba**			
^{138}Cs	55	83	137.911017(10)	33.41(18) min	β^-	**^{138}Ba**	3−		
^{138m}Cs	79.9(3) keV			2.91(8) min	IT (81%)	^{138}Cs	6−		
					β^- (19%)	**^{138}Ba**			
^{139}Cs	55	84	138.913364(3)	9.27(5) min	β^-	^{139}Ba	7/2+		
^{140}Cs	55	85	139.917282(9)	63.7(3) s	β^-	^{140}Ba	1−		
^{141}Cs	55	86	140.920046(11)	24.84(16) s	β^- (99.96%)	^{141}Ba	7/2+		
					β^-, n (.0349%)	^{140}Ba			
^{142}Cs	55	87	141.924299(11)	1.689(11) s	β^- (99.9%)	^{142}Ba	0−		
					β^-, n (.091%)	^{141}Ba			
^{143}Cs	55	88	142.927352(25)	1.791(7) s	β^- (98.38%)	^{143}Ba	3/2+		
					β^-, n (1.62%)	^{142}Ba			
^{144}Cs	55	89	143.932077(28)	994(4) ms	β^- (96.8%)	^{144}Ba	1(−#)		
					β^-, n (3.2%)	^{143}Ba			
^{144m}Cs	300(200)# keV			<1 s	β^-	^{144}Ba	(>3)		
					IT	^{144}Cs			
^{145}Cs	55	90	144.935526(12)	582(6) ms	β^- (85.7%)	^{145}Ba	3/2+		
					β^-, n (14.3%)	^{144}Ba			
^{146}Cs	55	91	145.94029(8)	0.321(2) s	β^- (85.8%)	^{146}Ba	1−		
					β^-, n (14.2%)	^{145}Ba			
^{147}Cs	55	92	146.94416(6)	0.235(3) s	β^- (71.5%)	^{147}Ba	(3/2+)		
					β^-, n (28.49%)	^{146}Ba			
^{148}Cs	55	93	147.94922(62)	146(6) ms	β^- (74.9%)	^{148}Ba			

					β⁻, n (25.1%)	^{147}Ba			
^{149}Cs	55	94	148.95293(21)#	150# ms [>50 ms]	β⁻	^{149}Ba	3/2+#		
					β⁻, n	^{148}Ba			
^{150}Cs	55	95	149.95817(32)#	100# ms [>50 ms]	β⁻	^{150}Ba			
					β⁻, n	^{149}Ba			
^{151}Cs	55	96	150.96219(54)#	60# ms [>50 ms]	β⁻	^{151}Ba	3/2+#		
					β⁻, n	^{150}Ba			

1. ^{m}Cs – 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. Modes of decay:
   - EC: Electron capture
   - IT: Isomeric transition
   - n: Neutron emission
   - p: Proton emission
5. ***Bold italics symbol*** as daughter – Daughter product is nearly stable.
6. **Bold symbol** as daughter – Daughter product is stable.
7. ( ) spin value – Indicates spin with weak assignment arguments.
8. # – Values marked # are not purely derived from experimental data, but at least partly from trends of neighboring nuclides (TNN).
9. Used to define the second
10. Fission product

Caesium-131

Caesium-131, introduced in 2004 for brachytherapy by Isoray,[4] has a half-life of 9.7 days and 30.4 keV energy.

Caesium-133

Caesium-133 is the only stable isotope of caesium. The SI base unit the second is defined by a specific caesium-133 transition. Since 2019, the official definition of a second is:

> The second, symbol s, is defined by taking the fixed numerical value of the caesium frequency $\Delta\nu_{Cs}$, the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom,[5] to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}.

Caesium-134

Caesium-134 has a half-life of 2.0652 years. It is produced both directly (at a very small yield because ^{134}Xe is stable) as a fission product and via neutron capture from nonradioactive ^{133}Cs (neutron capture cross section 29 barns), which is a common fission product. Caesium-134 is not produced via beta decay of other fission product nuclides of mass 134 since beta decay stops at stable ^{134}Xe. It is also not produced by nuclear weapons because ^{133}Cs is created by beta decay of original fission products only long after the nuclear explosion is over.

The combined yield of ^{133}Cs and ^{134}Cs is given as 6.7896%. The proportion between the two will change with continued neutron irradiation. ^{134}Cs also captures neutrons with a cross section of 140 barns, becoming long-lived radioactive ^{135}Cs.

Caesium-134 undergoes beta decay (β^-), producing ^{134}Ba directly and emitting on average 2.23 gamma ray photons (mean energy 0.698 MeV).[6]

Caesium-135

Caesium-135 is a mildly radioactive isotope of caesium with a half-life of 2.3 million years. It decays via emission of a low-energy beta particle into the stable isotope barium-135. Caesium-135 is one of the 7 long-lived fission products and the only alkaline one. In nuclear reprocessing, it stays with ^{137}Cs and other medium-lived fission products rather than with other long-lived fission products. The low decay energy, lack of gamma radiation, and long half-life of ^{135}Cs make this isotope much less hazardous than ^{137}Cs or ^{134}Cs.

Its precursor ^{135}Xe has a high fission product yield (e.g. 6.3333% for ^{235}U and thermal neutrons) but also has the highest known thermal neutron capture cross section of any nuclide. Because of this, much of the ^{135}Xe produced in current thermal reactors (as much as >90% at steady-state full power)[7] will be converted to stable ^{136}Xe before it can decay to ^{135}Cs. Little or no ^{135}Xe will be destroyed by neutron capture after a reactor shutdown, or in a molten salt reactor that continuously removes xenon from its fuel, a fast neutron reactor, or a nuclear weapon.

A nuclear reactor will also produce much smaller amounts of ^{135}Cs from the nonradioactive fission product ^{133}Cs by successive neutron capture to ^{134}Cs and then ^{135}Cs.

The thermal neutron capture cross section and resonance integral of ^{135}Cs are 8.3 ± 0.3 and 38.1 ± 2.6 barns respectively.[8] Disposal of ^{135}Cs by nuclear transmutation is difficult, because of the low cross section as well as because neutron irradiation of mixed-isotope fission caesium produces more ^{135}Cs from stable ^{133}Cs. In addition, the intense medium-term radioactivity of ^{137}Cs makes handling of nuclear waste difficult.[9]

- ANL factsheet (https://web.archive.org/web/20110429095603/http://www.ead.anl.gov/pub/doc/cesium.pdf)

Long-lived fission products

Nuclide	$t_{1/2}$	Yield	Decay energy[a 1]	Decay mode
	(Ma)	(%)[a 2]	(keV)	
^{99}Tc	0.211	6.1385	294	β
^{126}Sn	0.230	0.1084	4050[a 3]	βγ
^{79}Se	0.327	0.0447	151	β
^{93}Zr	1.53	5.4575	91	βγ
^{135}Cs	2.3	6.9110[a 4]	269	β
^{107}Pd	6.5	1.2499	33	β
^{129}I	15.7	0.8410	194	βγ

1. Decay energy is split among β, neutrino, and γ if any.
2. Per 65 thermal-neutron fissions of U-235 and 35 of Pu-239.
3. Has decay energy 380 keV, but decay product Sb-126 has decay energy 3.67 MeV.
4. Lower in thermal reactor because predecessor absorbs neutrons.

Caesium-136

Caesium-136 has a half-life of 13.16 days. It is produced both directly (at a very small yield because ^{136}Xe is beta-stable) as a fission product and via neutron capture from long-lived ^{135}Cs (neutron capture cross section 8.702 barns), which is a common fission product. Caesium-136 is not produced via beta decay of other fission product nuclides of mass 136 since beta decay stops at almost-stable ^{136}Xe. It is also not produced by nuclear weapons because ^{135}Cs is created by beta decay of original fission products only long after the nuclear explosion is over. ^{136}Cs also captures neutrons with a cross section of 13.00 barns, becoming medium-lived radioactive ^{137}Cs. Caesium-136 undergoes beta decay (β−), producing ^{136}Ba directly.

Caesium-137

Caesium-137, with a half-life of 30.17 years, is one of the two principal medium-lived fission products, along with ^{90}Sr, which are responsible for most of the radioactivity of spent nuclear fuel after several years of cooling, up to several hundred years after use. It constitutes most of the radioactivity still left from the Chernobyl accident and is a major health concern for decontaminating land near the Fukushima nuclear power plant.[10] ^{137}Cs beta decays to barium-137m (a short-lived nuclear isomer) then to nonradioactive barium-137, and is also a strong emitter of gamma radiation.

^{137}Cs has a very low rate of neutron capture and cannot yet be feasibly disposed of in this way unless advances in neutron beam collimation (not otherwise achievable by magnetic fields), uniquely available only from within muon catalyzed fusion experiments (not in the other forms of Accelerator Transmutation of Nuclear Waste) enables production of neutrons at high enough intensity to offset and overcome these low capture rates; until then, therefore, ^{137}Cs must simply be allowed to decay.

^{137}Cs has been used as a tracer in hydrologic studies, analogous to the use of ^{3}H.

Other isotopes of caesium

The other isotopes have half-lives from a few days to fractions of a second. Almost all caesium produced from nuclear fission comes from beta decay of originally more neutron-rich fission products, passing through isotopes of iodine then isotopes of xenon. Because these elements are volatile and can diffuse through nuclear fuel or air, caesium is often created far from the original site of fission.

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