Californium

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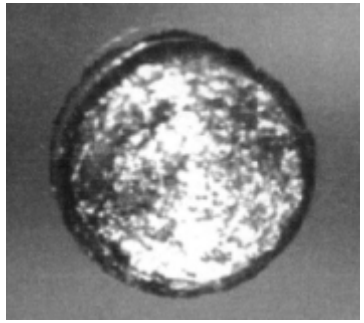
Californium is a radioactive metallic chemical element with symbol **Cf** and atomic number 98. The element was first made in 1950 at the University of California Radiation Laboratory in Berkeley, by bombarding curium with alpha particles (helium-4 ions). It is an actinide element, the sixth transuranium element to be synthesized, and has the second-highest atomic mass of all the elements that have been produced in amounts large enough to see with the unaided eye (after einsteinium). The element was named after the university and the state of California.

Two crystalline forms exist for californium under normal pressure: one above and one below 900 °C (1,650 °F). A third form exists at high pressure. Californium slowly tarnishes in air at room temperature. Compounds of californium are dominated by a chemical form of the element, designated californium(III), that can participate in three chemical bonds. The most stable of californium's twenty known isotopes is californium-251, which has a half-life of 898 years. This short half-life means the element is not found in significant quantities in the Earth's crust.[a] Californium-252, with a half-life of about 2.64 years, is the most common isotope used and is produced at the Oak Ridge National Laboratory in the United States and the Research Institute of Atomic Reactors in Russia.

Californium is one of the few transuranium elements that have practical applications. Most of these applications exploit the property of certain isotopes of californium to emit neutrons. For example, californium can be used to help start up nuclear reactors, and it is employed as a source of neutrons when studying materials with neutron diffraction and neutron spectroscopy. Californium can also be used in nuclear synthesis of higher mass elements; oganesson (element 118) was synthesized by bombarding californium-249 atoms with calcium-48 ions. Users of californium must take into account radiological concerns and the element's ability to disrupt the formation of red blood cells by bioaccumulating in skeletal tissue.

Characteristics

Californium, $_{98}$Cf



General properties	
Name, symbol	californium, Cf
Appearance	silvery
Californium in the periodic table	
Atomic number (Z)	98
Group, block	group n/a, f-block
Period	period 7
Element category	□ actinide
Standard atomic weight (A_r)	(251)[1]
Electron configuration	[Rn] $5f^{10}$ $7s^{2}$[2]
per shell	2, 8, 18, 32, 28, 8, 2
Physical properties	
Phase	solid
Melting point	1173 K (900 °C, 1652 °F)[1]
Boiling point	1743 K (1470 °C, 2678 °F) *(estimation)*[3]

Physical properties

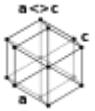
Californium is a silvery white actinide metal[10] with a melting point of 900 ± 30 °C (1,650 ± 50 °F) and an estimated boiling point of 1,745 K (1,470 °C; 2,680 °F).[11] The pure metal is malleable and is easily cut with a razor blade. Californium metal starts to vaporize above 300 °C (570 °F) when exposed to a vacuum.[12] Below 51 K (−220 °C) californium metal is either ferromagnetic or ferrimagnetic (it acts like a magnet), between 48 and 66 K it is antiferromagnetic (an intermediate state), and above 160 K (−113 °C; −172 °F) it is paramagnetic (external magnetic fields can make it magnetic).[13] It forms alloys with lanthanide metals but little is known about them.[12]

The element has two crystalline forms under 1 standard atmosphere of pressure: A double-hexagonal close-packed form dubbed alpha (α) and a face-centered cubic form designated beta (β).[b] The α form exists below 600–800 °C with a density of 15.10 g/cm^3 and the β form exists above 600–800 °C with a density of 8.74 g/cm^3.[15] At 48 GPa of pressure the β form changes into an orthorhombic crystal system due to delocalization of the atom's 5f electrons, which frees them to bond.[16][c]

The bulk modulus of a material is a measure of its resistance to uniform pressure. Californium's bulk modulus is 50 ± 5 GPa, which is similar to trivalent lanthanide metals but smaller than more familiar metals, such as aluminium (70 GPa).[16]

Chemical properties and compounds

Californium exhibits oxidation states of 4, 3, or 2. It typically forms eight or nine bonds to surrounding atoms or ions. Its chemical properties are predicted to be similar to other primarily 3+ valence actinide elements[18] and the element dysprosium, which is the lanthanide above californium in the periodic table.[19] The element slowly tarnishes in air at room temperature, with the

Density near r.t.	15.1 g/cm^3[1]
Atomic properties	
Oxidation states	2, **3**, 4[4]
Electronegativity	Pauling scale: 1.3[5]
Ionization energies	1st: 608 kJ/mol[6]
Miscellanea	
Crystal structure	double hexagonal close-packed (dhcp) 
Mohs hardness	3–4[7]
CAS Number	7440-71-3[1]
History	
Naming	after California, where it was discovered
Discovery	Lawrence Berkeley National Laboratory (1950)

Most stable isotopes of californium[8][9]

rate increasing when moisture is added.[15] Californium reacts when heated with hydrogen, nitrogen, or a chalcogen (oxygen family element); reactions with dry hydrogen and aqueous mineral acids are rapid.[15]

Californium is only water-soluble as the californium(III) cation. Attempts to reduce or oxidize the +3 ion in solution have failed.[19] The element forms a water-soluble chloride, nitrate, perchlorate, and sulfate and is precipitated as a fluoride, oxalate, or hydroxide.[18] Californium is the heaviest actinide to exhibit covalent properties, as is observed in the californium borate.[20]

Isotopes

Twenty radioisotopes of californium have been characterized, the most stable being californium-251 with a half-life of 898 years, californium-249 with a half-life of 351 years, californium-250 with a half-life of 13.08 years, and californium-252 with a half-life of 2.645 years.[9] All the remaining isotopes have half-lives shorter than a year, and the majority of these have half-lives shorter than 20 minutes.[9] The isotopes of californium range in mass number from 237 to 256.[9]

iso	NA	half-life	DM	DE (MeV)	DP
^{248}Cf	syn	333.5 d	α (100%)	6.369	^{244}Cm
			SF (2.9×10^{-3}%)	0.0029	–
^{249}Cf	syn	351 y	α (100%)	6.295	^{245}Cm
			SF (5.0×10^{-7}%)	4.4×10^{-7}	–
^{250}Cf	syn	13.08 y	α (99.92%)	6.129	^{246}Cm
			SF (0.08%)	0.077	–
^{251}Cf	syn	898 y	α	6.172	^{247}Cm
^{252}Cf	syn	2.645 y	α (96.91%)	6.217	^{248}Cm
			SF (3.09%)	–	–
^{253}Cf	syn	17.81 d	β^- (99.69%)	0.29	^{253}Es
			α (0.31%)	6.126	^{249}Cm
^{254}Cf	syn	60.5 d	SF (99.69%)	–	–
			α (0.31%)	5.930	^{250}Cm

Californium-249 is formed from the beta decay of berkelium-249, and most other californium isotopes are made by subjecting berkelium to intense neutron radiation in a nuclear reactor.[19] Although californium-251 has the longest half-life, its production yield is only 10% due to its tendency to collect neutrons (high neutron capture) and its tendency to interact with other particles (high neutron cross-section).[21]

Californium-252 is a very strong neutron emitter, which makes it extremely radioactive and harmful.[22][23][24] Californium-252 undergoes alpha decay 96.9% of the time to form curium-248 while the remaining 3.1% of decays are spontaneous fission.[9] One microgram (μg) of californium-252 emits 2.3 million neutrons per second, an average of 3.7 neutrons per spontaneous fission.[25] Most of the other isotopes of californium decay to isotopes of curium (atomic number 96) via alpha decay.[9]

Source

- Wikipedia: Californium (https://en.wikipedia.org/wiki/Californium)