

Americium

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Americium is a radioactive transuranic chemical element with symbol **Am** and atomic number 95. This member of the actinide series is located in the periodic table under the lanthanide element europium, and thus by analogy was named after the Americas.^[2]

Americium was first produced in 1944 by the group of Glenn T. Seaborg from Berkeley, California, at the Metallurgical Laboratory of the University of Chicago, a part of the Manhattan Project. Although it is the third element in the transuranic series, it was discovered fourth, after the heavier curium. The discovery was kept secret and only released to the public in November 1945. Most americium is produced by uranium or plutonium being bombarded with neutrons in nuclear reactors – one tonne of spent nuclear fuel contains about 100 grams of americium. It is widely used in commercial ionization chamber smoke detectors, as well as in neutron sources and industrial gauges. Several unusual applications, such as nuclear batteries or fuel for space ships with nuclear propulsion, have been proposed for the isotope ^{242m}Am, but they are as yet hindered by the scarcity and high price of this nuclear isomer.

Americium is a relatively soft radioactive metal with silvery appearance. Its common isotopes are ²⁴¹Am and ²⁴³Am. In chemical compounds, americium usually assumes the oxidation state +3, especially in solutions. Several other oxidation states are known, which range from +2 to +8 and can be identified by their characteristic optical absorption spectra. The crystal lattice of solid americium and its compounds contain small intrinsic radiogenic defects, due to metamictization induced by self-irradiation with alpha particles, which accumulates with time; this can cause a drift of some material properties over time, more noticeable in older samples.

Physical properties

In the periodic table, americium is located to the right of plutonium, to the left of curium, and below the lanthanide europium, with which it shares many similarities in physical and chemical properties. Americium is a highly radioactive element. When freshly prepared, it has a silvery-white metallic lustre, but then slowly tarnishes in air. With a density of 12 g/cm³, americium is less dense than both curium (13.52 g/cm³) and

Americium, ⁹⁵Am



Spectral lines of americium

General properties

Name, symbol	americium, Am
Appearance	silvery white

Americium in the periodic table

Atomic number (<i>Z</i>)	95
Group, block	group n/a, f-block
Period	period 7
Element category	☐ actinide
Standard atomic weight (<i>A</i> _r)	(243)
Electron configuration	[Rn] 5f ⁷ 7s ²
per shell	2, 8, 18, 32, 25, 8,

plutonium (19.8 g/cm³); but has a higher density than europium (5.264 g/cm³)—mostly because of its higher atomic mass. Americium is relatively soft and easily deformable and has a significantly lower bulk modulus than the actinides before it: Th, Pa, U, Np and Pu.^[39] Its melting point of 1173 °C is significantly higher than that of plutonium (639 °C) and europium (826 °C), but lower than for curium (1340 °C).^{[38][38][40]}

At ambient conditions, americium is present in its most stable α form which has a hexagonal crystal symmetry, and a space group $P6_3/mmc$ with lattice parameters $a = 346.8$ pm and $c = 1124$ pm, and four atoms per unit cell. The crystal consists of a double-hexagonal close packing with the layer sequence ABAC and so is isotypic with α -lanthanum and several actinides such as α -curium.^{[36][40]} The crystal structure of americium changes with pressure and temperature. When compressed at room temperature to 5 GPa, α -Am transforms to the β modification, which has a face-centered cubic (*fcc*) symmetry, space group $Fm\bar{3}m$ and lattice constant $a = 489$ pm. This *fcc* structure is equivalent to the closest packing with the sequence ABC.^{[36][40]} Upon further compression to 23 GPa, americium transforms to an orthorhombic γ -Am structure similar to that of α -uranium. There are no further transitions observed up to 52 GPa, except for an appearance of a monoclinic phase at pressures between 10 and 15 GPa.^[39] There is no consistency on the status of this phase in the literature, which also sometimes lists the α , β and γ phases as I, II and III. The β - γ transition is accompanied by a 6% decrease in the crystal volume; although theory also predicts a significant volume change for the α - β transition, it is not observed experimentally. The pressure of the α - β transition decreases with increasing temperature, and when α -americium is heated at ambient pressure, at 770 °C it changes into an *fcc* phase which is different from β -Am, and at 1075 °C it converts to a body-centered cubic structure. The pressure-temperature phase diagram of americium is thus rather similar to those of lanthanum, praseodymium and neodymium.^[41]

As with many other actinides, self-damage of the crystal lattice due to alpha-particle irradiation is intrinsic to americium. It is especially noticeable at low temperatures, where the mobility of the produced lattice defects is relatively low, by broadening of X-ray diffraction peaks. This effect makes somewhat uncertain the temperature of americium and some of its properties, such as electrical resistivity.^[42] So for americium-241, the resistivity at 4.2 K increases with time from about 2 $\mu\text{Ohm}\cdot\text{cm}$ to 10 $\mu\text{Ohm}\cdot\text{cm}$ after 40 hours, and saturates at about 16 $\mu\text{Ohm}\cdot\text{cm}$ after 140 hours. This effect is less

Physical properties

Phase	solid
Melting point	1449 K (1176 °C, 2149 °F)
Boiling point	2880 K (2607 °C, 4725 °F) (calculated)
Density near r.t.	12 g/cm ³
Heat of fusion	14.39 kJ/mol
Molar heat capacity	62.7 J/(mol·K)

Vapor pressure

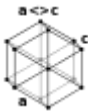
P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	1239	1356				

Atomic properties

Oxidation states	8, 7, 6, 5, 4, 3 , 2 (an amphoteric oxide)
Electronegativity	Pauling scale: 1.3
Ionization energies	1st: 578 kJ/mol
Atomic radius	empirical: 173 pm
Covalent radius	180±6 pm

Miscellanea

Crystal structure	double hexagonal close-packed (dhcp)
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Thermal conductivity	10 W/(m·K)
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pronounced at room temperature, due to annihilation of radiation defects; also heating to room temperature the sample which was kept for hours at low temperatures restores its resistivity. In fresh samples, the resistivity gradually increases with temperature from about 2 μOhm·cm at liquid helium to 69 μOhm·cm at room temperature; this behavior is similar to that of neptunium, uranium, thorium and protactinium, but is different from plutonium and curium which show a rapid rise up to 60 K followed by saturation. The room temperature value for americium is lower than that of neptunium, plutonium and curium, but higher than for uranium, thorium and protactinium.^[1]

Americium is paramagnetic in a wide temperature range, from that of liquid helium, to room temperature and above. This behavior is markedly different from that of its neighbor curium which exhibits antiferromagnetic transition at 52 K.^[43] The thermal expansion coefficient of americium is slightly anisotropic and amounts to $(7.5 \pm 0.2) \times 10^{-6}/^{\circ}\text{C}$ along the shorter *a* axis and $(6.2 \pm 0.4) \times 10^{-6}/^{\circ}\text{C}$ for the longer *c* hexagonal axis.^[40] The enthalpy of dissolution of americium metal in hydrochloric acid at standard conditions is -620.6 ± 1.3 kJ/mol, from which the standard enthalpy change of formation ($\Delta_f H^{\circ}$) of aqueous Am³⁺ ion is -621.2 ± 2.0 kJ/mol⁻¹. The standard potential Am³⁺/Am⁰ is -2.08 ± 0.01 V.^[44]

Chemical properties

Americium readily reacts with oxygen and dissolves well in acids. The most common oxidation state for americium is +3,^[45] in which americium compounds are rather stable against oxidation and reduction. In this sense, americium is chemically similar to most lanthanides. The trivalent americium forms insoluble fluoride, oxalate, iodate, hydroxide, phosphate and other salts.^[45] Other oxidation states have been observed between +2 and +7, which is the widest range among the actinide elements. Their color in aqueous solutions varies as follows: Am³⁺ (colorless to yellow-reddish), Am⁴⁺ (yellow-reddish), Am^{VO₂⁺} (yellow), Am^{VO₂²⁺} (brown) and Am^{VO₆⁵⁻} (dark green).^{[46][47]} All oxidation states have their characteristic optical absorption spectra, with a few sharp peaks in the visible and mid-infrared regions, and the position and intensity of these peaks can be converted into the concentrations of the corresponding oxidation states.^{[48][49][50]} For example, Am(III) has two sharp peaks at 504 and 811 nm, Am(V) at 514 and 715 nm, and Am(VI) at 666 and 992 nm.^[51]

Electrical resistivity

0.69 μΩ·m^[1]

Magnetic ordering

paramagnetic

CAS Number

7440-35-9

History

Naming

after the Americas

Discovery

Glenn T. Seaborg,
Ralph A. James,
Leon O. Morgan,
Albert Ghiorso
(1944)

Most stable isotopes of americium

iso	NA	half-life	DM	DE (MeV)	DP
²⁴¹ Am	syn	432.2 y	SF	–	–
			α	5.486	²³⁷ Np
^{242m1} Am	syn	141 y	IT	0.049	²⁴² Am
			α	5.637	²³⁸ Np
			SF	–	–
²⁴³ Am	syn	7370 y	SF	–	–
			α	5.275	²³⁹ Np

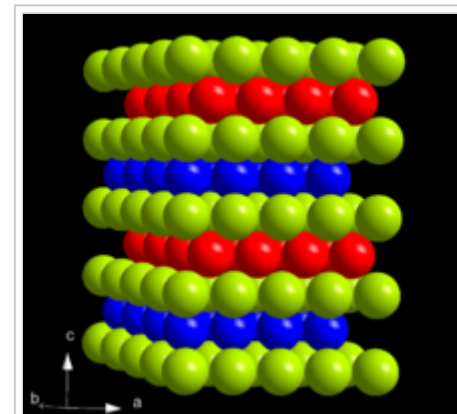
Americium compounds with oxidation state +4 and higher are strong oxidizing agents, comparable in strength to the permanganate ion (MnO_4^-) in acidic solutions.^[52] Whereas the Am^{4+} ions are unstable in solutions and readily convert to Am^{3+} , the +4 oxidation state occurs well in solids, such as americium dioxide (AmO_2) and americium(IV) fluoride (AmF_4).

All pentavalent and hexavalent americium compounds are complex salts such as KAmO_2F_2 , Li_3AmO_4 and Li_6AmO_6 , Ba_3AmO_6 , AmO_2F_2 . These high oxidation states Am(IV), Am(V) and Am(VI) can be prepared from Am(III) by oxidation with ammonium persulfate in dilute nitric acid,^[53] with silver(I) oxide in perchloric acid,^[51] or with ozone or sodium persulfate in sodium carbonate solutions.^[50] The pentavalent oxidation state of americium was first observed in 1951.^[54] It is present in aqueous solution in the form of AmO_2^+ ions (acidic) or AmO_3^- ions (alkaline) which are however unstable and subject to several rapid disproportionation reactions:^{[55][56][57]}



Source

- Wikipedia: Americium (<https://en.wikipedia.org/wiki/Americium>)



Double-hexagonal close packing with the layer sequence ABAC in the crystal structure of α -americium (A: green, B: blue, C: red).