Francium

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Francium is a chemical element with symbol **Fr** and atomic number 87. It used to be known as eka-caesium and actinium K.^[note 1] It is the second-least electronegative element, behind only caesium, and is the second rarest naturally occurring element (after astatine). Francium is a highly radioactive metal that decays into astatine, radium, and radon. As an alkali metal, it has one valence electron.

Bulk francium has never been viewed. Because of the general appearance of the other elements in its periodic table column, it is assumed that francium would appear as a highly reactive metal, if enough could be collected together to be viewed as a bulk solid or liquid. Obtaining such a sample is highly improbable, since the extreme heat of decay (the half-life of its longest-lived isotope is only 22 minutes) would immediately vaporize any viewable quantity of the element.

Francium was discovered by Marguerite Perey in France (from which the element takes its name) in 1939. It was the last element first discovered in nature, rather than by synthesis. [note 2] Outside the laboratory, francium is extremely rare, with trace amounts found in uranium and thorium ores, where the isotope francium-223 continually forms and decays. As little as 20–30 g (one ounce) exists at any given time throughout the Earth's crust; the other isotopes (except for francium-221) are entirely synthetic. The largest amount produced in the laboratory was a cluster of more than 300,000 atoms. [3]

Characteristics

Francium is one of the most unstable of the naturally occurring elements: its longest-lived isotope, francium-223, has a half-life of only 22 minutes. The only comparable element is astatine, whose most stable *natural* isotope, astatine-219 (the alpha daughter of francium-223), has a half-life of 56 seconds, although synthetic astatine-210 is much longer-lived with a half-life of 8.1 hours. [4] All isotopes of francium decay into astatine, radium, or radon. [4] Francium-223 also has a shorter half-life than the longest-lived isotope of each synthetic element up to and including element 105, dubnium. [5]

Francium, 87Fr

General properties

Name, symbol francium, Fr

Pronunciation /ˈfrænsiəm/

FRAN-See-əm

Francium in the periodic table

Atomic number (Z) 87

Group, block group 1 (alkali metals),

s-block

Period period 7

Standard atomic

weight (A_r)

(223)

[Rn] 7s¹

Electron configuration

per shell 2, 8, 18, 32, 18, 8, 1

Physical properties

Phase solid presumably

Melting point ? 300 K (30 °C, 80 °F)

Boiling point ? 950 K (680 °C,

1300 °F)

Density near r.t. $2.8-3.0 \text{ g/cm}^3$

(extrapolated)[1]

Vapor pressure (extrapolated)

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	404	454	519	608	738	946

Francium is an alkali metal whose chemical properties mostly resemble those of caesium.^[5] A heavy element with a single valence electron,^[6] it has the highest equivalent weight of any element.^[5] Liquid francium—if created—should have a surface tension of 0.05092 N/m at its melting point.^[7] Francium's melting point was calculated to be around 27 °C (80 °F, 300 K).^[8] The melting point is uncertain because of the element's extreme rarity and radioactivity. Thus, the estimated boiling point value of 677 °C (1250 °F, 950 K) is also uncertain.

Linus Pauling estimated the electronegativity of francium at 0.7 on the Pauling scale, the same as caesium; $^{[9]}$ the value for caesium has since been refined to 0.79, but there are no experimental data to allow a refinement of the value for francium. $^{[10]}$ Francium has a slightly higher ionization energy than caesium, $^{[11]}$ 392.811(4) kJ/mol as opposed to 375.7041(2) kJ/mol for caesium, as would be expected from relativistic effects, and this would imply that caesium is the less electronegative of the two. Francium should also have a higher electron affinity than caesium and the Fr $^-$ ion should be more polarizable than the Cs $^-$ ion. $^{[12]}$ The CsFr molecule is predicted to have francium at the negative end of the dipole, unlike all known heterodiatomic alkali metal molecules. Francium superoxide (FrO₂) is expected to have a more covalent character than its lighter congeners; this is attributed to the 6p electrons in francium being more involved in the francium-oxygen bonding. $^{[12]}$

Francium coprecipitates with several caesium salts, such as caesium perchlorate, which results in small amounts of francium perchlorate. This coprecipitation can be used to isolate francium, by adapting the radiocaesium coprecipitation method of Glendenin and Nelson. It will additionally coprecipitate with many other caesium salts, including the iodate, the picrate, the tartrate (also rubidium tartrate), the chloroplatinate, and the silicotungstate. It also coprecipitates with silicotungstic acid, and with perchloric acid, without another alkali metal as a carrier, which provides other methods of separation. [13][14] Nearly all francium salts are water-soluble. [15]

Isotopes

Atomic properties

Oxidation states +1 (a strongly basic

oxide)

Electronegativity Pauling scale: >0.79

Ionization energies

1st: 393^[2] kJ/mol

Covalent radius 260 pm (extrapolated)

Van der Waals 348 pm (extrapolated)

radius

Miscellanea

Crystal structure body-centered cubic

(bcc)

(extrapolated)

Thermal 15 W/(m⋅K) **conductivity** (extrapolated)

Electrical resistivity

 $3 \mu\Omega \cdot m$ (calculated)

Magnetic ordering Paramagnetic

CAS Number 7440-73-5

History

Naming after France, homeland

of the discoverer

Discovery and Marguerite Perey

first isolation (1939)

Most stable isotopes of francium

iso	NA	half-life	DM	DE (MeV)	DP
²²¹ Fr	trace	4.8 min	α	6.457	²¹⁷ At
²²² Fr	syn	14.2 min	β-	2.033	²²² Ra
²²³ Fr	trace	22.00 min	β-	1.149	²²³ Ra
			α	5.430	²¹⁹ At

There are 34 known isotopes of francium ranging in atomic mass from 199 to 232. [16] Francium has seven metastable nuclear isomers. [5] Francium-223 and francium-221 are the only isotopes that occur in nature, though the former is far more common. [17]

Francium-223 is the most stable isotope, with a half-life of 21.8 minutes,^[5] and it is highly unlikely that an isotope of francium with a longer half-life will ever be discovered or synthesized.^[18] Francium-223 is the fifth product of the actinium decay series as the daughter isotope of actinium-227.^[19] Francium-223 then decays into radium-223 by beta decay (1149 keV decay energy), with a minor (0.006%) alpha decay path to astatine-219 (5.4 MeV decay energy).^[20]

Francium-221 has a half-life of 4.8 minutes.^[5] It is the ninth product of the neptunium decay series as a daughter isotope of actinium-225.^[19] Francium-221 then decays into astatine-217 by alpha decay (6.457 MeV decay energy).^[5]

The least stable ground state isotope is francium-215, with a half-life of 0.12 μ s. (9.54 MeV alpha decay to a statine-211):^[5] Its metastable isomer, francium-215m, is less stable still, with a half-life of only 3.5 ns.^[21]

Source

Wikipedia: Francium (https://en.wikipedia.org/wiki/Francium)