Actinium

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Actinium is a radioactive chemical element with symbol **Ac** (not to be confused with the abbreviation for an acetyl group) and atomic number 89, which was discovered in 1899. It was the first non-primordial radioactive element to be isolated. Polonium, radium and radon were observed before actinium, but they were not isolated until 1902. Actinium gave the name to the actinide series, a group of 15 similar elements between actinium and lawrencium in the periodic table. It is also sometimes considered the first of the 7th-period transition metals, although lawrencium is less commonly given that position.

A soft, silvery-white radioactive metal, actinium reacts rapidly with oxygen and moisture in air forming a white coating of actinium oxide that prevents further oxidation. As with most lanthanides and many actinides, actinium assumes oxidation state +3 in nearly all its chemical compounds. Actinium is found only in traces in uranium and thorium ores as the isotope ^{227}Ac, which decays with a half-life of 21.772 years, predominantly emitting beta and sometimes alpha particles, and ^{228}Ac, which is beta active with a half-life of 6.15 hours. One tonne of natural uranium in ore contains about 0.2 milligrams of actinium-227, and one tonne of natural thorium contains about 5 nanograms of actinium-228. The close similarity of physical and chemical properties of actinium and lanthanum makes separation of actinium from the ore impractical. Instead, the element is prepared, in milligram amounts, by the neutron irradiation of ^{226}Ra in a nuclear reactor. Owing to its scarcity, high price and radioactivity, actinium has no significant industrial use. Its current applications include a neutron source and an agent for radiation therapy targeting cancer cells in the body.

Properties

Actinium is a soft, silvery-white,[15][16] radioactive, metallic element. Its estimated shear modulus is similar to that of lead.[17] Owing to its strong radioactivity, actinium glows in the dark with a pale blue light, which originates from the surrounding air ionized by the emitted energetic particles.[18] Actinium has similar chemical properties to lanthanum

Actinium, $_{89}$Ac

General properties	
Name, symbol	actinium, Ac
Appearance	silvery-white, glowing with an eerie blue light;[1] sometimes with a golden cast[2]
Actinium in the periodic table	
Atomic number (*Z*)	89
Group, block	group n/a, f-block
Period	period 7
Element category	actinide, sometimes considered a transition metal

and other lanthanides, and therefore these elements are difficult to separate when extracting from uranium ores. Solvent extraction and ion chromatography are commonly used for the separation.[19]

The first element of the actinides, actinium gave the group its name, much as lanthanum had done for the lanthanides. The group of elements is more diverse than the lanthanides and therefore it was not until 1928 that Charles Janet proposed the most significant change to Dmitri Mendeleev's periodic table since the recognition of the lanthanides, by introducing the actinides, a move suggested again in 1945 by Glenn T. Seaborg.[20]

Actinium reacts rapidly with oxygen and moisture in air forming a white coating of actinium oxide that impedes further oxidation.[15] As with most lanthanides and actinides, actinium exists in the oxidation state +3, and the Ac^{3+} ions are colorless in solutions.[21] The oxidation state +3 originates from the $[Rn]6d^17s^2$ electronic configuration of actinium, with three valence electrons that are easily donated to give the stable closed-shell structure of the noble gas radon.[16] The rare oxidation state +2 is only known for actinium dihydride (AcH_2).[22]

Chemical compounds

Only a limited number of actinium compounds are known including AcF_3, $AcCl_3$, $AcBr_3$, AcOF, AcOCl, AcOBr, Ac_2S_3, Ac_2O_3 and $AcPO_4$. Except for $AcPO_4$, they are all similar to the corresponding lanthanum compounds. They all contain actinium in the oxidation state +3.[21][23] In particular, the lattice constants of the analogous lanthanum and actinium compounds differ by only a few percent.[24]

Here *a*, *b* and *c* are lattice constants, No is space group number and *Z* is the number of formula units per unit cell. Density was not measured directly but calculated from the lattice parameters.

Oxides

Standard atomic weight (A_r)	(227)
Electron configuration	$[Rn]\ 6d^1\ 7s^2$
per shell	2, 8, 18, 32, 18, 9, 2
Physical properties	
Phase	solid
Melting point	1500 K (1227 °C, 2240 °F) *(estimated)*[2]
Boiling point	3500±300 K (3200±300 °C, 5800±500 °F) *(extrapolated)*[2]
Density near r.t.	10 g/cm^3
Heat of fusion	14 kJ/mol
Heat of vaporization	400 kJ/mol
Molar heat capacity	27.2 J/(mol·K)
Atomic properties	
Oxidation states	**3**, 2 (a neutral oxide)
Electronegativity	Pauling scale: 1.1
Ionization energies	1st: 499 kJ/mol 2nd: 1170 kJ/mol 3rd: 1900 kJ/mol (more)
Covalent radius	215 pm
Miscellanea	
Crystal structure	face-centered

Actinium oxide (Ac_2O_3) can be obtained by heating the hydroxide at 500 °C or the oxalate at 1100 °C, in vacuum. Its crystal lattice is isotypic with the oxides of most trivalent rare-earth metals.[24]

Halides

Actinium trifluoride can be produced either in solution or in solid reaction. The former reaction is carried out at room temperature, by adding hydrofluoric acid to a solution containing actinium ions. In the latter method, actinium metal is treated with hydrogen fluoride vapors at 700 °C in an all-platinum setup. Treating actinium trifluoride with ammonium hydroxide at 900–1000 °C yields oxyfluoride AcOF. Whereas lanthanum oxyfluoride can be easily obtained by burning lanthanum trifluoride in air at 800 °C for an hour, similar treatment of actinium trifluoride yields no AcOF and only results in melting of the initial product.[24][29]

$$AcF_3 + 2\ NH_3 + H_2O \rightarrow AcOF + 2\ NH_4F$$

Actinium trichloride is obtained by reacting actinium hydroxide or oxalate with carbon tetrachloride vapors at temperatures above 960 °C. Similar to oxyfluoride, actinium oxychloride can be prepared by hydrolyzing actinium trichloride with ammonium hydroxide at 1000 °C. However, in contrast to the oxyfluoride, the oxychloride could well be synthesized by igniting a solution of actinium trichloride in hydrochloric acid with ammonia.[24]

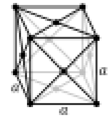
Reaction of aluminium bromide and actinium oxide yields actinium tribromide:

$$Ac_2O_3 + 2\ AlBr_3 \rightarrow 2\ AcBr_3 + Al_2O_3$$

and treating it with ammonium hydroxide at 500 °C results in the oxybromide AcOBr.[24]

Other compounds

Actinium hydride was obtained by reduction of actinium trichloride with potassium at 300 °C, and its structure was deduced by analogy with the corresponding LaH_2 hydride. The source of hydrogen in the reaction was uncertain.[30]

	cubic (fcc) 
Thermal conductivity	12 W/(m·K)
CAS Number	7440-34-8
History	
Discovery and first isolation	Friedrich Oskar Giesel (1902)
Named by	André-Louis Debierne (1899)

Most stable isotopes of actinium

iso	NA	half-life	DM	DE (MeV)	DP
^{225}Ac	trace	10 d	α	5.935	^{221}Fr
^{226}Ac	syn	29.37 h	β^-	1.117	^{226}Th
			ε	0.640	^{226}Ra
			α	5.536	^{222}Fr
^{227}Ac	trace	21.772 y	β^-	0.045	^{227}Th
			α	5.042	^{223}Fr

Mixing monosodium phosphate (NaH_2PO_4) with a solution of actinium in hydrochloric acid yields white-colored actinium phosphate hemihydrate ($AcPO_4 \cdot 0.5H_2O$), and heating actinium oxalate with hydrogen sulfide vapors at 1400 °C for a few minutes results in a black actinium sulfide Ac_2S_3. It may possibly be produced by acting with a mixture of hydrogen sulfide and carbon disulfide on actinium oxide at 1000 °C.[24]

Isotopes

Naturally occurring actinium is composed of two radioactive isotopes; ^{227}Ac (from the radioactive family of ^{235}U) and ^{228}Ac (a granddaughter of ^{232}Th). ^{227}Ac decays mainly as a beta emitter with a very small energy, but in 1.38% of cases it emits an alpha particle, so it can readily be identified through alpha spectrometry.[2] Thirty-six radioisotopes have been identified, the most stable being ^{227}Ac with a half-life of 21.772 years, ^{225}Ac with a half-life of 10.0 days and ^{226}Ac with a half-life of 29.37 hours. All remaining radioactive isotopes have half-lives that are less than 10 hours and the majority of them have half-lives shorter than one minute. The shortest-lived known isotope of actinium is ^{217}Ac (half-life of 69 nanoseconds) which decays through alpha decay and electron capture. Actinium also has two known meta states.[31] The most significant isotopes for chemistry are ^{225}Ac, ^{227}Ac, and ^{228}Ac.[2]

Purified ^{227}Ac comes into equilibrium with its decay products after about a half of year. It decays according to its 21.772-year half-life emitting mostly beta (98.62%) and some alpha particles (1.38%);[31] the successive decay products are part of the actinium series. Owing to the low available amounts, low energy of its beta particles (maximum 44.8 keV) and low intensity of alpha radiation, ^{227}Ac is difficult to detect directly by its emission and it is therefore traced via its decay products.[21] The isotopes of actinium range in atomic weight from 206 u (^{206}Ac) to 236 u (^{236}Ac).[31]

External links

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