Hafnium

From Wikipedia, the free encyclopedia

Hafnium is a chemical element with symbol **Hf** and atomic number 72. A lustrous, silvery gray, tetravalent transition metal, hafnium chemically resembles zirconium and is found in zirconium minerals. Its existence was predicted by Dmitri Mendeleev in 1869, though it was not identified until 1923, making it the penultimate stable element to be discovered (rhenium was identified two years later). Hafnium is named after *Hafnia*, the Latin name for Copenhagen, where it was discovered.[3][4]

Hafnium is used in filaments and electrodes. Some semiconductor fabrication processes use its oxide for integrated circuits at 45 nm and smaller feature lengths. Some superalloys used for special applications contain hafnium in combination with niobium, titanium, or tungsten.

Hafnium's large neutron capture cross-section makes it a good material for neutron absorption in control rods in nuclear power plants, but at the same time requires that it be removed from the neutron-transparent corrosion-resistant zirconium alloys used in nuclear reactors.

Hafnium, $_{72}$Hf

Spectral lines of hafnium (400–700 nm)

General properties	
Name, symbol	hafnium, Hf
Appearance	steel gray
Hafnium in the periodic table	
Atomic number (Z)	72
Group, block	group 4, d-block
Period	period 6
Element category	▯ transition metal
Standard atomic weight (±) (A_r)	178.49(2)[1]
Electron configuration	[Xe] $4f^{14}$ $5d^2$ $6s^2$
per shell	2, 8, 18, 32, 10, 2
Physical properties	
Phase	solid
Melting point	2506 K (2233 °C, 4051 °F)
Boiling point	4876 K (4603 °C, 8317 °F)
Density near r.t.	13.31 g/cm^3

Characteristics

Physical characteristics

Hafnium bits

Hafnium is a shiny, silvery, ductile metal that is corrosion-resistant and chemically similar to zirconium[5] (due to not only to its having the same number of valence electrons and being in the same group, but also to relativistic effects). The physical properties of hafnium metal samples are markedly affected by zirconium impurities, especially the nuclear properties, as these two elements are among the most difficult to separate because of their chemical similarity.[5]

A notable physical difference between these metals is their density, with zirconium having about one-half the density of hafnium. The most notable nuclear properties of hafnium are its high thermal neutron-capture cross-section and that the nuclei of several different hafnium isotopes readily absorb two or more neutrons apiece.[5] In contrast with this, zirconium is practically transparent to thermal neutrons, and it is commonly used for the metal components of nuclear reactors – especially the cladding of their nuclear fuel rods.

Chemical characteristics


Hafnium dioxide

Hafnium reacts in air to form a protective film that inhibits further corrosion. The metal is not readily attacked by acids but can be oxidized with halogens or it can be burnt in air. Like its sister metal zirconium, finely divided hafnium can ignite spontaneously in air, producing an effect similar to that obtained in Dragon's Breath.[6] The metal is resistant to concentrated alkalis.

The chemistry of hafnium and zirconium is so similar that the two cannot be separated on the basis of differing chemical reactions. The melting points and boiling points of the compounds and the solubility in solvents are the major differences in the chemistry of these twin elements.[7]

Isotopes

At least 34 isotopes of hafnium have been observed, ranging in mass number from 153 to 186.[8][9] The five stable isotopes are in the range of 176 to 180. The radioactive isotopes' half-lives range from only 400 ms for ^{153}Hf,[9] to 2.0 petayears (10^{15} years) for the most stable one, ^{174}Hf.[8]

The nuclear isomer ^{178m2}Hf was at the center of a controversy for several years regarding its potential use as a weapon.

when liquid, at m.p.	12 g/cm^3
Heat of fusion	27.2 kJ/mol
Heat of vaporization	648 kJ/mol
Molar heat capacity	25.73 J/(mol·K)

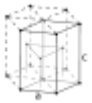
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	2689	2954	3277	3679	4194	4876

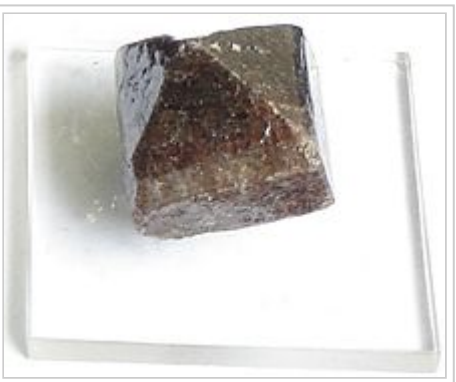
Atomic properties

Oxidation states	**4**, 3, 2, 1, −2 (an amphoteric oxide)
Electronegativity	Pauling scale: 1.3
Ionization energies	1st: 658.5 kJ/mol 2nd: 1440 kJ/mol 3rd: 2250 kJ/mol
Atomic radius	empirical: 159 pm
Covalent radius	175±10 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	3010 m/s (at 20 °C)
Thermal expansion	5.9 µm/(m·K) (at 25 °C)
Thermal conductivity	23.0 W/(m·K)
Electrical resistivity	331 nΩ·m (at 20 °C)
Magnetic ordering	paramagnetic[2]
Young's modulus	78 GPa

Occurrence


Zircon crystal (2×2 cm) from Tocantins, Brazil

Hafnium is estimated to make up about 5.8 ppm of the Earth's upper crust by mass. It does not exist as a free element on Earth, but is found combined in solid solution with zirconium in natural zirconium compounds such as zircon, $ZrSiO_4$, which usually has about 1 – 4% of the Zr replaced by Hf. Rarely, the Hf/Zr ratio increases during crystallization to give the isostructural mineral "hafnon" $(Hf,Zr)SiO_4$, with atomic Hf > Zr.[10] An old (obsolete) name for a variety of zircon containing unusually high Hf content is *alvite*.[11]

A major source of zircon (and hence hafnium) ores is heavy mineral sands ore deposits, pegmatites, particularly in Brazil and Malawi, and carbonatite intrusions, particularly the Crown Polymetallic Deposit at Mount Weld, Western Australia. A potential source of hafnium is trachyte tuffs containing rare zircon-hafnium silicates eudialyte or armstrongite, at Dubbo in New South Wales, Australia.[12]

Hafnium reserves have been infamously estimated to last under 10 years by one source if the world population increases and demand grows.[13] In reality, since hafnium occurs with zirconium, hafnium can always be a byproduct of zirconium extraction to the extent that the low demand requires.

External links

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

Shear modulus	30 GPa
Bulk modulus	110 GPa
Poisson ratio	0.37
Mohs hardness	5.5
Vickers hardness	1520–2060 MPa
Brinell hardness	1450–2100 MPa
CAS Number	7440-58-6
History	
Naming	after *Hafnia*. Latin for: Copenhagen, where it was discovered
Prediction	Dmitri Mendeleev (1869)
Discovery and first isolation	Dirk Coster and George de Hevesy (1922)

Most stable isotopes of hafnium

iso	NA	half-life	DM	DE (MeV)	DP
^{172}Hf	syn	1.87 y	ε	0.350	^{172}Lu
^{174}Hf	0.16%	2×10^{15} y	α	2.495	^{170}Yb
^{176}Hf	5.26%	is stable with 104 neutrons			
^{177}Hf	18.60%	is stable with 105 neutrons			
^{178}Hf	27.28%	is stable with 106 neutrons			
^{178m2}Hf	syn	31 y	IT	2.446	^{178}Hf
^{179}Hf	13.62%	is stable with 107 neutrons			
^{180}Hf	35.08%	is stable with 108 neutrons			
^{182}Hf	syn	8.9×10^{6} y	β^-	0.373	^{182}Ta