

Holmium

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Holmium is a chemical element with symbol **Ho** and atomic number 67. Part of the lanthanide series, holmium is a rare earth element. Holmium was discovered by Swedish chemist Per Theodor Cleve. Its oxide was first isolated from rare earth ores in 1878 and the element was named after the city of Stockholm.

Elemental holmium is a relatively soft and malleable silvery-white metal. It is too reactive to be found uncombined in nature, but when isolated, is relatively stable in dry air at room temperature. However, it reacts with water and corrodes readily, and will also burn in air when heated.

Holmium is found in the minerals monazite and gadolinite, and is usually commercially extracted from monazite using ion exchange techniques. Its compounds in nature, and in nearly all of its laboratory chemistry, are trivalently oxidized, containing Ho(III) ions. Trivalent holmium ions have fluorescent properties similar to many other rare earth ions (while yielding their own set of unique emission light lines), and holmium ions are thus used in the same way as some other rare earths in certain laser and glass colorant applications.

Holmium has the highest magnetic permeability of any element and therefore is used for the polepieces of the strongest static magnets. Because holmium strongly absorbs neutrons, it is also used as a burnable poison in nuclear reactors.

Characteristics

Physical properties

Holmium is a relatively soft and malleable element that is fairly corrosion-resistant and stable in dry air at standard temperature and pressure. In moist air and at higher temperatures, however, it quickly oxidizes, forming a yellowish oxide. In pure form, holmium possesses a metallic, bright silvery luster.

Holmium, ${}_{67}\text{Ho}$



General properties

Name, symbol	holmium, Ho
Appearance	silvery white

Holmium in the periodic table

Atomic number (<i>Z</i>)	67
Group, block	group n/a, f-block
Period	period 6
Element category	☐ lanthanide
Standard atomic weight (\pm) (<i>A</i> _r)	164.93033(2) ^[1]
Electron configuration	[Xe] 4f ¹¹ 6s ²
per shell	2, 8, 18, 29, 8, 2

Physical properties

Phase	solid
Melting point	1734 K (1461 °C, 2662 °F)



Ho₂O₃, left: natural light, right: under a cold cathode fluorescent lamp

Holmium oxide has some fairly dramatic color changes depending on the lighting conditions. In daylight, it is a tannish yellow color. Under trichromatic light, it is a fiery orange red, almost indistinguishable from the appearance of erbium oxide under the same lighting conditions. The perceived color change is related to the sharp absorption bands of holmium interacting with a subset of the sharp emission bands of the trivalent ions of europium and terbium, acting as phosphors.^[2]

Holmium has the highest magnetic moment (10.6 μ_B) of any naturally occurring element and possesses other unusual magnetic properties. When combined with yttrium, it forms highly

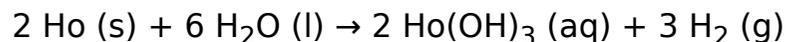
magnetic compounds.^[3] Holmium is paramagnetic at ambient conditions, but is ferromagnetic at temperatures below 19 K.^[4]

Chemical properties

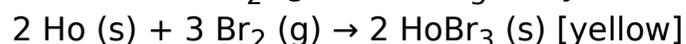
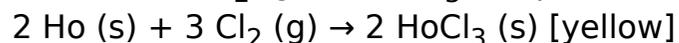
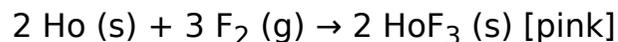
Holmium metal tarnishes slowly in air and burns readily to form holmium(III) oxide:



Holmium is quite electropositive and is generally trivalent. It reacts slowly with cold water and quite quickly with hot water to form holmium hydroxide:



Holmium metal reacts with all the halogens:



Boiling point	2873 K (2600 °C, 4712 °F)
Density near r.t.	8.79 g/cm ³
when liquid, at m.p.	8.34 g/cm ³
Heat of fusion	17.0 kJ/mol
Heat of vaporization	251 kJ/mol
Molar heat capacity	27.15 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	1432	1584	(1775)	(2040)	(2410)	(2964)

Atomic properties

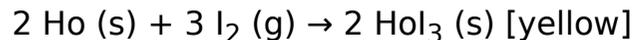
Oxidation states	3, 2, 1 (a basic oxide)
Electronegativity	Pauling scale: 1.23
Ionization energies	1st: 581.0 kJ/mol 2nd: 1140 kJ/mol 3rd: 2204 kJ/mol
Atomic radius	empirical: 176 pm
Covalent radius	192±7 pm

Miscellanea

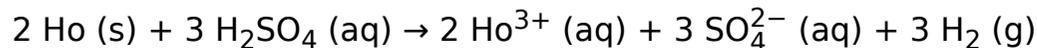
Crystal structure	hexagonal close-packed (hcp)
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Speed of sound thin rod	2760 m/s (at 20 °C)
Thermal expansion	poly: 11.2 μm/(m·K) (at r.t.)
Thermal conductivity	16.2 W/(m·K)
Electrical resistivity	poly: 814 nΩ·m (at r.t.)
Magnetic ordering	paramagnetic
Young's modulus	64.8 GPa



Holmium dissolves readily in dilute sulfuric acid to form solutions containing the yellow Ho(III) ions, which exist as a $[\text{Ho}(\text{OH}_2)_9]^{3+}$ complexes:[5]



Holmium's most common oxidation state is +3. Holmium in solution is in the form of Ho^{3+} surrounded by nine molecules of water. Holmium dissolves in acids.[6]

Isotopes

Natural holmium contains one stable isotope, holmium-165. Some synthetic radioactive isotopes are known; the most stable one is holmium-163, with a half life of 4570 years. All other radioisotopes have ground-state half lives not greater than 1.117 days, and most have half lives under 3 hours. However, the metastable $^{166\text{m}1}\text{Ho}$ has a half life of around 1200 years because of its high spin. This fact, combined with a high excitation energy resulting in a particularly rich spectrum of decay gamma rays produced when the metastable state de-excites, makes this isotope useful in nuclear physics experiments as a means for calibrating energy responses and intrinsic efficiencies of gamma ray spectrometers.

Source

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

Shear modulus	26.3 GPa
Bulk modulus	40.2 GPa
Poisson ratio	0.231
Vickers hardness	410–600 MPa
Brinell hardness	500–1250 MPa
CAS Number	7440-60-0

History

Discovery Jacques-Louis Soret (1878)

Most stable isotopes of holmium

iso	NA	half-life	DM	DE (MeV)	DP
¹⁶³Ho	syn	4570 y	ε	0.003	¹⁶³ Dy
¹⁶⁴Ho	syn	29 min	ε	0.987	¹⁶⁴ Dy
¹⁶⁵Ho	100%	is stable with 98 neutrons			
¹⁶⁶Ho	syn	26.763 h	β ⁻	1.855	¹⁶⁶ Er
¹⁶⁷Ho	syn	3.1 h	β ⁻	1.007	¹⁶⁷ Er