Dysprosium

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Dysprosium is a chemical element with the symbol **Dy** and atomic number 66. It is a rare earth element with a metallic silver luster. Dysprosium is never found in nature as a free element, though it is found in various minerals, such as xenotime. Naturally occurring dysprosium is composed of seven isotopes, the most abundant of which is ^{164}Dy.

Dysprosium was first identified in 1886 by Paul Émile Lecoq de Boisbaudran, but was not isolated in pure form until the development of ion exchange techniques in the 1950s. Dysprosium is used for its high thermal neutron absorption cross-section in making control rods in nuclear reactors, for its high magnetic susceptibility in data storage applications, and as a component of Terfenol-D (a magnetostrictive material). Soluble dysprosium salts are mildly toxic, while the insoluble salts are considered non-toxic.

Characteristics

Physical properties

Dysprosium sample

Dysprosium is a rare earth element that has a metallic, bright silver luster. It is soft enough to be cut with a knife, and can be machined without sparking if overheating is avoided. Dysprosium's physical characteristics can be greatly affected by even small amounts of impurities.[2]

Dysprosium and holmium have the highest magnetic strengths of the elements,[3] especially at low temperatures.[4] Dysprosium has a simple ferromagnetic ordering at temperatures below 85 K (−188.2 °C). Above 85 K (−188.2 °C), it turns into an helical antiferromagnetic state in which all of the atomic moments in a particular basal plane layer are parallel, and oriented at a fixed angle to the moments of adjacent layers. This unusual antiferromagnetism transforms into a disordered (paramagnetic) state at 179 K (−94 °C).[5]

Dysprosium, $_{66}$Dy

General properties	
Name, symbol	dysprosium, Dy
Pronunciation	/dɪs'proʊziəm/ *dis-**PROH**-zee-əm*
Appearance	silvery white
Dysprosium in the periodic table	
Atomic number (*Z*)	66
Group, block	group n/a, f-block
Period	period 6
Element category	□ lanthanide
Standard atomic weight (±) (A_r)	162.500(1)[1]
Electron configuration	[Xe] $4f^{10}$ $6s^2$
per shell	2, 8, 18, 28, 8, 2
Physical properties	
Phase	solid
Melting point	1680 K (1407 °C,

Chemical properties

Dysprosium metal tarnishes slowly in air and burns readily to form dysprosium(III) oxide:

$$4\ Dy + 3\ O_2 \rightarrow 2\ Dy_2O_3$$

Dysprosium is quite electropositive and reacts slowly with cold water (and quite quickly with hot water) to form dysprosium hydroxide:

$$2\ Dy\ (s) + 6\ H_2O\ (l) \rightarrow 2\ Dy(OH)_3\ (aq) + 3\ H_2\ (g)$$

Dysprosium metal vigorously reacts with all the halogens at above 200 °C:

$$2\ Dy\ (s) + 3\ F_2\ (g) \rightarrow 2\ DyF_3\ (s)\ [green]$$
$$2\ Dy\ (s) + 3\ Cl_2\ (g) \rightarrow 2\ DyCl_3\ (s)\ [white]$$
$$2\ Dy\ (s) + 3\ Br_2\ (g) \rightarrow 2\ DyBr_3\ (s)\ [white]$$
$$2\ Dy\ (s) + 3\ I_2\ (g) \rightarrow 2\ DyI_3\ (s)\ [green]$$

Dysprosium dissolves readily in dilute sulfuric acid to form solutions containing the yellow Dy(III) ions, which exist as a $[Dy(OH_2)_9]^{3+}$ complex:[6]

$$2\ Dy\ (s) + 3\ H_2SO_4\ (aq) \rightarrow 2\ Dy^{3+}\ (aq) + 3\ SO_4^{2-}\ (aq) + 3\ H_2\ (g)$$

The resulting compound, dysprosium(III) sulfate, is noticeably paramagnetic.

Compounds

Dysprosium halides, such as DyF_3 and $DyBr_3$, tend to take on a yellow color. Dysprosium oxide, also known as dysprosia, is a white powder that is highly magnetic, more so than iron oxide.[4]

Dysprosium combines with various non-metals at high temperatures to form binary compounds with varying composition and oxidation states +3 and sometimes +2, such as DyN, DyP, DyH_2 and DyH_3; DyS, DyS_2, Dy_2S_3 and Dy_5S_7;

	2565 °F)
Boiling point	2840 K (2562 °C, 4653 °F)
Density near r.t.	8.540 g/cm^3
when liquid, at m.p.	8.37 g/cm^3
Heat of fusion	11.06 kJ/mol
Heat of vaporization	280 kJ/mol
Molar heat capacity	27.7 J/(mol·K)

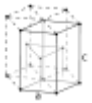
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1378	1523	(1704)	(1954)	(2304)	(2831)

Atomic properties

Oxidation states	4, **3**, 2, 1 (a weakly basic oxide)
Electronegativity	Pauling scale: 1.22
Ionization energies	1st: 573.0 kJ/mol 2nd: 1130 kJ/mol 3rd: 2200 kJ/mol
Atomic radius	empirical: 178 pm
Covalent radius	192±7 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	2710 m/s (at 20 °C)
Thermal expansion	α, poly: 9.9 µm/(m·K) (r.t.)
Thermal conductivity	10.7 W/(m·K)
Electrical resistivity	α, poly: 926 nΩ·m (r.t.)

Dysprosium sulfate, $Dy_2(SO_4)_3$

DyB_2, DyB_4, DyB_6 and DyB_{12}, as well as Dy_3C and Dy_2C_3.[7]

Dysprosium carbonate, $Dy_2(CO_3)_3$, and dysprosium sulfate, $Dy_2(SO_4)_3$, result from similar reactions.[8] Most dysprosium compounds are soluble in water, though dysprosium carbonate tetrahydrate ($Dy_2(CO_3)_3{\cdot}4H_2O$) and dysprosium oxalate decahydrate ($Dy_2(C_2O_4)_3{\cdot}10H_2O$) are both insoluble in water.[9][10] Two of the most abundant dysprosium carbonates, tengerite-(Dy) ($Dy_2(CO_3)_3{\cdot}2–3H_2O$) and kozoite-(Dy) ($DyCO_3(OH)$) are known to form via a poorly ordered (amorphous) precursor phase with a formula of $Dy_2(CO_3)_3{\cdot}4H_2O$. This amorphous precursor consists of highly hydrated spherical nanoparticles of 10–20 nm diameter that are exceptionally stable under dry treatment at ambient and high temperatures.[11]

Magnetic ordering	paramagnetic at 300 K
Young's modulus	α form: 61.4 GPa
Shear modulus	α form: 24.7 GPa
Bulk modulus	α form: 40.5 GPa
Poisson ratio	α form: 0.247
Vickers hardness	410–550 MPa
Brinell hardness	500–1050 MPa
CAS Number	7429-91-6
History	
Discovery	Lecoq de Boisbaudran (1886)

Most stable isotopes of dysprosium

iso	NA	half-life	DM	DE (MeV)	DP
^{154}Dy	syn	3.0×10^{6} y	α	2.947	^{150}Gd
^{156}Dy	0.056%	is stable with 90 neutrons			
^{158}Dy	0.095%	is stable with 92 neutrons			
^{160}Dy	2.329%	is stable with 94 neutrons			
^{161}Dy	18.889%	is stable with 95 neutrons			
^{162}Dy	25.475%	is stable with 96 neutrons			
^{163}Dy	24.896%	is stable with 97 neutrons			
^{164}Dy	28.260%	is stable with 98 neutrons			

Isotopes

Naturally occurring dysprosium is composed of seven isotopes: ^{156}Dy, ^{158}Dy, ^{160}Dy, ^{161}Dy, ^{162}Dy, ^{163}Dy, and ^{164}Dy. These are all considered stable, although ^{156}Dy decays by alpha decay with a half-life of over 1×10^{18} years. Of the naturally occurring isotopes, ^{164}Dy is the most abundant at 28%, followed by ^{162}Dy at 26%. The least abundant is ^{156}Dy at 0.06%.[12]

Twenty-nine radioisotopes have also been synthesized, ranging in atomic mass from 138 to 173. The most stable of these is ^{154}Dy, with a half-life of approximately 3×10^{6} years, followed by ^{159}Dym with a half-life of 144.4 days. The least stable is ^{138}Dy, with a half-life of 200 ms. As a general rule, isotopes that are lighter than the stable isotopes tend to decay primarily by β^+ decay, while those that are heavier tend to decay by β^- decay. However, ^{154}Dy decays primarily by alpha decay, and ^{152}Dy and ^{159}Dy decay primarily by electron capture.[12] Dysprosium also has at least 11 metastable isomers, ranging in atomic mass from 140 to 165. The most stable of these is ^{165m}Dy, which has a half-life of 1.257 minutes. ^{149}Dy has two metastable isomers, the second of which, ^{149m2}Dy, has a half-life of 28 ns.[12]

Source

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