

Praseodymium

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Praseodymium is a chemical element with symbol **Pr** and atomic number 59. Praseodymium is a soft, silvery, malleable and ductile metal in the lanthanide group. It is valued for its magnetic, electrical, chemical, and optical properties.^[4] It is too reactive to be found in native form, and when artificially prepared, it slowly develops a green oxide coating.

The element was named for the color of its primary oxide. In 1841, Swedish chemist Carl Gustav Mosander extracted a rare earth oxide residue he called "didymium" from a residue he called "lanthana", in turn separated from cerium salts. In 1885, the Austrian chemist Baron Carl Auer von Welsbach separated didymium into two salts of different colors, which he named praseodymium and neodymium. The name praseodymium comes from the Greek *prasinós* (πράσινος), meaning "green", and *didymos* (δίδυμος), "twin".

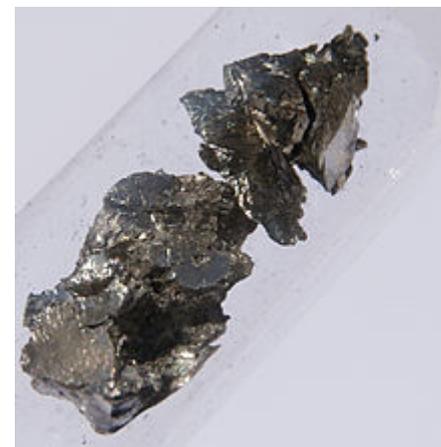
Like most rare earth elements, praseodymium most readily forms trivalent Pr(III) ions. These are yellow-green in water solution, and various shades of yellow-green when incorporated into glasses. Many of praseodymium's industrial uses involve its use to filter yellow light from light sources.

Characteristics

Physical properties

Praseodymium is a soft, silvery, malleable, and ductile metal in the lanthanide group. It is somewhat more resistant to corrosion in air than europium, lanthanum, cerium, or neodymium, but it does develop a green oxide coating that spalls off when exposed to air, exposing more metal to oxidation—a centimeter-sized sample of Pr completely oxidizes within a year.^[5] For this reason, praseodymium is usually stored under a light mineral oil or sealed in glass.

Praseodymium, ⁵⁹Pr



General properties

Name, symbol	praseodymium, Pr
Appearance	grayish white

Praseodymium in the periodic table

Atomic number (<i>Z</i>)	59
Group, block	group n/a, f-block
Period	period 6
Element category	☐ lanthanide
Standard atomic weight (\pm) (<i>A</i> _r)	140.90766(2) ^[2]
Electron configuration	[Xe] 4f ³ 6s ²
per shell	2, 8, 18, 21, 8, 2

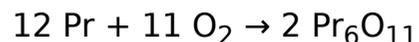
Physical properties

Phase	solid
Melting point	

Unlike other rare-earth metals, which show antiferromagnetic or/and ferromagnetic ordering at low temperatures, Pr is paramagnetic at any temperature above 1 K.^[3]

Chemical properties

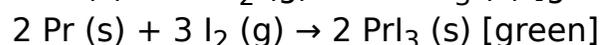
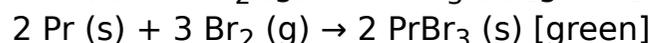
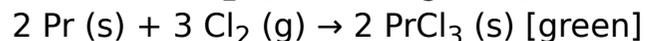
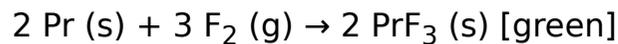
Praseodymium metal tarnishes slowly in air and burns readily at 150 °C to form praseodymium(III,IV) oxide:



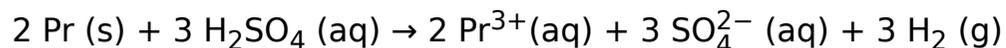
Praseodymium is quite electropositive and reacts slowly with cold water and quite quickly with hot water to form praseodymium (III) hydroxide:



Praseodymium metal reacts with all the halogens:



Praseodymium dissolves readily in dilute sulfuric acid to form solutions containing green Pr(III) ions, which exist as a $[\text{Pr(OH}_2)_9]^{3+}$ complexes:^[6]



Compounds

In its compounds, praseodymium occurs in oxidation states +2, +3, +4, and uniquely among the lanthanides, +5. Praseodymium(IV) is a strong oxidant, instantly oxidizing water to elemental oxygen (O₂), or hydrochloric acid to elemental chlorine (Cl₂). Thus, in aqueous solution, only the +3 oxidation state is encountered. Praseodymium(III) salts are yellow-green and, in solution, present a fairly simple absorption spectrum in the visible region, with a band in the yellow-

Boiling point	1208 K (935 °C, 1715 °F)
Density near r.t.	3403 K (3130 °C, 5666 °F)
when liquid, at m.p.	6.77 g/cm ³
Heat of fusion	6.50 g/cm ³
Heat of vaporization	6.89 kJ/mol
Molar heat capacity	331 kJ/mol
	27.20 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	1771	1973	(2227)	(2571)	(3054)	(3779)

Atomic properties

Oxidation states	5, 4, 3 , 2 (a mildly basic oxide)
Electronegativity	Pauling scale: 1.13
Ionization energies	1st: 527 kJ/mol 2nd: 1020 kJ/mol 3rd: 2086 kJ/mol
Atomic radius	empirical: 182 pm
Covalent radius	203±7 pm

Miscellanea

Crystal structure	double hexagonal close-packed (dhcp)
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Speed of sound thin rod	2280 m/s (at 20 °C)
Thermal expansion	α, poly: 6.7 μm/(m·K) (at r.t.)
Thermal conductivity	12.5 W/(m·K)

orange at 589–590 nm (which coincides with the sodium emission doublet), and three bands in the blue/violet region, at 444, 468, and 482 nm, approximately. These positions vary slightly with the counter-ion. Praseodymium oxide, as obtained by the ignition of salts such as the oxalate or carbonate in air, is essentially black in color (with a hint of brown or green) and contains +3 and +4 praseodymium in a somewhat variable ratio, depending upon the conditions of formation. Its formula is conventionally rendered as Pr₆O₁₁. Although praseodymium(V) in the bulk state is unknown, the existence of praseodymium in its +5 oxidation state (corresponding to the [Xe]4f⁰5d⁰ configuration) under noble-gas matrix isolation conditions was reported in 2016. The species assigned to the +5 state were identified as [PrO₂]⁺, its O₂ and Ar adducts, and PrO₂(η²-O₂).^[7]

Other praseodymium compounds include:

- Fluorides: PrF₂, PrF₃, PrF₄
- Chlorides: PrCl₃
- Bromides: PrBr₃, Pr₂Br₅
- Iodides: PrI₂, PrI₃, Pr₂I₅
- Oxides: PrO₂, Pr₂O₃, Pr₆O₁₁
- Sulfides: PrS, Pr₂S₃
- Sulfates: Pr₂(SO₄)₃
- Selenides: PrSe
- Tellurides: PrTe, Pr₂Te₃
- Nitrides: PrN
- Carbonates: Pr₂(CO₃)₃^[8]

Isotopes

Naturally occurring praseodymium is composed of one stable isotope, praseodymium-141,^[9] which is of use in NMR and EPR spectroscopy.^[10] 38 radioisotopes have been characterized, with the most stable being praseodymium-143 with a half-life of 13.57 days and praseodymium-142 with a half-life of 19.12 hours.^[9] All of the remaining radioactive isotopes have half-lives that are less than six hours, and the majority of these have half-lives that are less than 10 minutes.^[9] This element also has 15

Electrical resistivity	α, poly: 0.700 μΩ·m (at r.t.)
Magnetic ordering	paramagnetic ^[3]
Young's modulus	α form: 37.3 GPa
Shear modulus	α form: 14.8 GPa
Bulk modulus	α form: 28.8 GPa
Poisson ratio	α form: 0.281
Vickers hardness	250–745 MPa
Brinell hardness	250–640 MPa
CAS Number	7440-10-0

History

Discovery Carl Auer von Welsbach (1885)

Most stable isotopes of praseodymium

iso	NA	half-life	DM	DE (MeV)	DP
141Pr	100%	is stable with 82 neutrons			
142Pr	syn	19.12 h	β [−]	2.162	¹⁴² Nd
			ε	0.745	¹⁴² Ce
143Pr	syn	13.57 d	β [−]	0.934	¹⁴³ Nd

nuclear isomers, with the longest-lived being praseodymium-138m, praseodymium-134m, and praseodymium-142m.^[9] The nuclei of nuclear isomers exist in a delicate equilibrium or metastability due to at least one nucleon having an excited energy state.

The isotopes of praseodymium range in mass number from 121 to 159.^[9] The most common decay mode of 20 isotopes with mass numbers lower than the most abundant stable isotope, praseodymium-141 is β^+ decay, primarily forming cerium isotopes (58 protons) as decay products.^[9] The most common decay mode for 18 isotopes with mass numbers higher than praseodymium-141 is β^- decay, primarily forming neodymium isotopes (60 protons) as decay products.^[9]

Source

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