

Niobium

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Niobium, formerly **columbium**, is a chemical element with symbol **Nb** (formerly **Cb**) and atomic number 41. It is a soft, grey, ductile transition metal, which is often found in the pyrochlore mineral, the main commercial source for niobium, and columbite. The name comes from Greek mythology: *Niobe*, daughter of *Tantalus* since it is so similar to tantalum.^[2]

Niobium has physical and chemical properties similar to those of the element tantalum, and the two are difficult to distinguish. The English chemist Charles Hatchett reported a new element similar to tantalum in 1801 and named it columbium. In 1809, the English chemist William Hyde Wollaston wrongly concluded that tantalum and columbium were identical. The German chemist Heinrich Rose determined in 1846 that tantalum ores contain a second element, which he named niobium. In 1864 and 1865, a series of scientific findings clarified that niobium and columbium were the same element (as distinguished from tantalum), and for a century both names were used interchangeably. Niobium was officially adopted as the name of the element in 1949, but the name columbium remains in current use in metallurgy in the United States.

It was not until the early 20th century that niobium was first used commercially. Brazil is the leading producer of niobium and ferroniobium, an alloy of niobium and iron which has a niobium content of 60-70%. Niobium is used mostly in alloys, the largest part in special steel such as that used in gas pipelines. Although these alloys contain a maximum of 0.1%, the small percentage of niobium enhances the strength of the steel. The temperature stability of niobium-containing superalloys is important for its use in jet and rocket engines.

Niobium is used in various superconducting materials. These superconducting alloys, also containing titanium and tin, are widely used in the superconducting magnets of MRI scanners. Other applications of niobium include welding, nuclear industries, electronics, optics, numismatics, and jewelry. In the last two applications, the low toxicity and iridescence produced by anodization are highly desired properties.

Characteristics

Niobium, $_{41}\text{Nb}$



General properties

Name, symbol	niobium, Nb
Alternative name	columbium
Appearance	gray metallic, bluish when oxidized

Niobium in the periodic table

Atomic number (<i>Z</i>)	41
Group, block	group 5, d-block
Period	period 5
Element category	☐ transition metal
Standard atomic weight (\pm) (<i>A</i> _r)	92.90637(2) ^[1]
Electron configuration	[Kr] 4d ⁴ 5s ¹
per shell	2, 8, 18, 12, 1

Physical properties

Phase	solid
Melting point	2750 K (2477 °C, 4491 °F)
Boiling point	5017 K (4744 °C,

Physical

Niobium is a lustrous, grey, ductile, paramagnetic metal in Group 5 of the periodic table (see table), with an electron configuration in the outermost shells atypical for Group 5. (This can be observed in the neighborhood of ruthenium (44), rhodium (45), and palladium (46).)

Although it is thought to have a body-centered cubic Crystal structure from $T = 0$ K to its melting point, high-resolution measurements of the thermal expansion along the three crystallographic axes reveal anisotropies which are inconsistent with a cubic structure.^[26] Therefore, further research and discovery in this area is expected.

Niobium becomes a superconductor at cryogenic temperatures. At atmospheric pressure, it has the highest critical temperature of the elemental superconductors: 9.2 K.^[27] Niobium has the greatest magnetic penetration depth of any element.^[27] In addition, it is one of the three elemental Type II superconductors, along with vanadium and technetium. The superconductive properties are strongly dependent on the purity of the niobium metal.^[28]

When very pure, it is comparatively soft and ductile, but impurities make it harder.^[29]

The metal has a low capture cross-section for thermal neutrons;^[30] thus it is used in the nuclear industries where neutron transparent structures are desired.^[31]

Chemical

The metal takes on a bluish tinge when exposed to air at room temperature for extended periods.^[32] Despite a high melting point in elemental form (2,468 °C), it has a lower density than other refractory metals. Furthermore, it is corrosion-resistant, exhibits superconductivity properties, and forms dielectric oxide layers.

Niobium is slightly less electropositive and more compact than its predecessor in the periodic table, zirconium, whereas it is virtually identical in size to the heavier tantalum atoms, as a result of the lanthanide contraction.^[29] As a result, niobium's chemical properties are very similar to those for tantalum, which appears directly

8571 °F)

Density near r.t. 8.57 g/cm³

Heat of fusion 30 kJ/mol

Heat of vaporization 689.9 kJ/mol

Molar heat capacity 24.60 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	2942	3207	3524	3910	4393	5013

Atomic properties

Oxidation states 5, 4, 3, 2, 1, −1, −3 (a mildly acidic oxide)

Electronegativity Pauling scale: 1.6

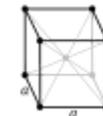
Ionization energies
1st: 652.1 kJ/mol
2nd: 1380 kJ/mol
3rd: 2416 kJ/mol

Atomic radius empirical: 146 pm

Covalent radius 164±6 pm

Miscellanea

Crystal structure body-centered cubic (bcc)



Speed of sound 3480 m/s (at 20 °C)
thin rod

Thermal expansion 7.3 μm/(m·K)

Thermal conductivity 53.7 W/(m·K)

Electrical resistivity 152 nΩ·m (at 0 °C)

Magnetic ordering paramagnetic

below niobium in the periodic table.^[13] Although its corrosion resistance is not as outstanding as that of tantalum, the lower price and greater availability make niobium attractive for less demanding applications, such as vat linings in chemical plants.^[29]

Isotopes

Niobium in the Earth's crust comprises one stable isotope, ⁹³Nb.^[33] By 2003, at least 32 radioisotopes had been synthesized, ranging in atomic mass from 81 to 113. The most stable of these is ⁹²Nb with a half-life of 34.7 million years. One of the least stable is ¹¹³Nb, with an estimated half-life of 30 milliseconds. Isotopes that are lighter than the stable ⁹³Nb tend to decay by β^+ decay, and those that are heavier tend to decay by β^- decay, with some exceptions. ⁸¹Nb, ⁸²Nb, and ⁸⁴Nb have minor β^+ delayed proton emission decay paths, ⁹¹Nb decays by electron capture and positron emission, and ⁹²Nb decays by both β^+ and β^- decay.^[33]

At least 25 nuclear isomers have been described, ranging in atomic mass from 84 to 104. Within this range, only ⁹⁶Nb, ¹⁰¹Nb, and ¹⁰³Nb do not have isomers. The most stable of niobium's isomers is ^{93m}Nb with a half-life of 16.13 years. The least stable isomer is ^{84m}Nb with a half-life of 103 ns. All of niobium's isomers decay by isomeric transition or beta decay except ^{92m1}Nb, which has a minor electron capture decay chain.^[33]

Occurrence

Niobium is estimated to be the 34th most common element in the Earth's crust, with 20 ppm.^[34] Some think that the abundance on Earth is much greater, and that the element's high density has concentrated it in the Earth's core.^[24] The free element is not found in nature, but niobium occurs in combination with other elements in minerals.^[29] Minerals that contain niobium often also contain tantalum. Examples include columbite ((Fe,Mn)(Nb,Ta)₂O₆) and columbite-tantalite (or *coltan*, (Fe,Mn)(Ta,Nb)₂O₆).^[35] Columbite-tantalite minerals are most usually found as accessory

Young's modulus	105 GPa
Shear modulus	38 GPa
Bulk modulus	170 GPa
Poisson ratio	0.40
Mohs hardness	6.0
Vickers hardness	870–1320 MPa
Brinell hardness	735–2450 MPa
CAS Number	7440-03-1

History

Naming	after Niobe in Greek mythology, daughter of Tantalus (tantalum)
Discovery	Charles Hatchett (1801)
First isolation	Christian Wilhelm Blomstrand (1864)
Recognized as a distinct element by	Heinrich Rose (1844)

Most stable isotopes of niobium

minerals in pegmatite intrusions, and in alkaline intrusive rocks. Less common are the niobates of calcium, uranium, thorium and the rare earth elements. Examples of such niobates are pyrochlore ((Na,Ca)₂Nb₂O₆(OH,F)) and euxenite ((Y,Ca,Ce,U,Th)(Nb,Ta,Ti)₂O₆). These large deposits of niobium have been found associated with carbonatites (carbonate-silicate igneous rocks) and as a constituent of pyrochlore.^[36]

The three largest currently mined deposits of pyrochlore, two in Brazil and one in Canada, were founded in the 1950s, and are still the major producers of niobium mineral concentrates.^[13] The largest deposit is hosted within a carbonatite intrusion in Araxá, state of Minas Gerais, Brazil, owned by CBMM (Companhia Brasileira de Metalurgia e Mineração); the other active Brazilian deposit is located near Catalão, state of Goiás, and owned by China Molybdenum, also hosted within a carbonatite intrusion.^[37] Together, those two mines produce about 88% of the world's supply.^[38] Brazil also has a large but still unexploited deposit near São Gabriel da Cachoeira, state of Amazonas, as well as a few smaller deposits, notably in the state of Roraima.^[38]

The third largest producer of niobium is the carbonatite-hosted Niobec mine, in Saint-Honoré, near Chicoutimi, Quebec, Canada, owned by Magris Resources.^[39] It produces between 7% and 10% of the world's supply.^{[37][38]}

External links

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

iso	NA	half-life	DM	DE (MeV)	DP
90Nb	syn	14.6 h	β ⁺	–	⁹⁰ Zr
91Nb	syn	680 y	ε	–	⁹¹ Zr
91mNb	syn	60.86 d	IT	0.104e	⁹¹ Nb
92m1Nb	syn	10.15 d	ε	–	⁹² Zr
			γ	0.934	–
92Nb	trace	3.47×10 ⁷ y	ε	–	⁹² Zr
			γ	0.561, 0.934	–
93Nb	100%	is stable with 52 neutrons			
93mNb	syn	16.13 y	IT	0.031e	⁹³ Nb
94Nb	trace	20300 y	β [−]	0.471	⁹⁴ Mo
			γ	0.702, 0.871	–
95Nb	syn	34.991 d	β [−]	0.159	⁹⁵ Mo
			γ	0.765	–
95mNb	syn	3.61 d	IT	0.235	⁹⁵ Nb
96Nb	syn	23.4 h	β [−]	–	⁹⁶ Mo