

Zirconium

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Zirconium is a chemical element with symbol **Zr** and atomic number 40. The name of zirconium is taken from the name of the mineral zircon, the most important source of zirconium. The word *zircon* comes from the Persian word *zargun* زرگون, meaning "gold-colored".^[5] It is a lustrous, grey-white, strong transition metal that resembles hafnium and, to a lesser extent, titanium. Zirconium is mainly used as a refractory and opacifier, although small amounts are used as an alloying agent for its strong resistance to corrosion. Zirconium forms a variety of inorganic and organometallic compounds such as zirconium dioxide and zirconocene dichloride, respectively. Five isotopes occur naturally, three of which are stable. Zirconium compounds have no known biological role.

Characteristics

Zirconium is a lustrous, greyish-white, soft, ductile and malleable metal that is solid at room temperature, though it is hard and brittle at lesser purities.^{[6][7]} In powder form, zirconium is highly flammable, but the solid form is much less prone to ignition. Zirconium is highly resistant to corrosion by alkalis, acids, salt water and other agents.^[8] However, it will dissolve in hydrochloric and sulfuric acid, especially when fluorine is present.^[9] Alloys with zinc are magnetic at less than 35 K.^[8]

The melting point of zirconium is 1855 °C (3371 °F), and the boiling point is 4371 °C (7900 °F).^[8] Zirconium has an electronegativity of 1.33 on the Pauling scale. Of the elements within the d-block, zirconium has the fourth lowest electronegativity after yttrium, lanthanum (or lutetium), and hafnium.^[10]

At room temperature zirconium exhibits a hexagonally close packed crystal structure, α -Zr, which changes to β -Zr a body-centered cubic crystal structure at 863 °C. Zirconium exists in the β -phase until the melting point.^[11]

Isotopes

Zirconium, ⁴⁰Zr



General properties

Name, symbol	zirconium, Zr
Appearance	silvery white

Zirconium in the periodic table

Atomic number (<i>Z</i>)	40
Group, block	group 4, d-block
Period	period 5
Element category	☐ transition metal
Standard atomic weight (\pm) (<i>A</i> _r)	91.224(2) ^[1]
Electron configuration	[Kr] 4d ² 5s ²
per shell	2, 8, 18, 10, 2

Physical properties

Phase	solid
Melting point	2128 K (1855 °C, 3371 °F)
Boiling point	4650 K (4377 °C,

Naturally occurring zirconium is composed of five isotopes. ⁹⁰Zr, ⁹¹Zr, ⁹²Zr and ⁹⁴Zr are stable, although ⁹⁴Zr is predicted to undergo double beta decay (not observed experimentally) with a half-life of more than 1.10×10¹⁷ years. ⁹⁶Zr has a half-life of 2.4×10¹⁹ years, and is the longest-lived radioisotope of zirconium. Of these natural isotopes, ⁹⁰Zr is the most common, making up 51.45% of all zirconium. ⁹⁶Zr is the least common, comprising only 2.80% of zirconium.^[12]

Twenty-eight artificial isotopes of zirconium have been synthesized, ranging in atomic mass from 78 to 110. ⁹³Zr is the longest-lived artificial isotope, with a half-life of 1.53×10⁶ years. ¹¹⁰Zr, the heaviest isotope of zirconium, is the most radioactive, with an estimated half-life of 30 milliseconds. Radioactive isotopes at or above mass number 93 decay by electron emission, whereas those at or below 89 decay by positron emission. The only exception is ⁸⁸Zr, which decays by electron capture.^[12]

Five isotopes of zirconium also exist as metastable isomers: ^{83m}Zr, ^{85m}Zr, ^{89m}Zr, ^{90m1}Zr, ^{90m2}Zr and ^{91m}Zr. Of these, ^{90m2}Zr has the shortest half-life at 131 nanoseconds. ^{89m}Zr is the longest lived with a half-life of 4.161 minutes.^[12]

Occurrence

Zirconium has a concentration of about 130 mg/kg within the Earth's crust and about 0.026 µg/L in sea water.^[13] It is not found in nature as a native metal, reflecting its intrinsic instability with respect to water. The principal commercial source of zirconium is zircon (ZrSiO₄), a silicate mineral,^[6] which is found primarily in Australia, Brazil, India, Russia, South Africa and the United States, as well as in smaller deposits around the world.^[7] As of 2013, two-thirds of zircon mining occurs in Australia and South Africa.^[14] Zircon resources exceed 60 million tonnes worldwide^[15] and annual worldwide zirconium production is approximately 900,000 tonnes.^[13] Zirconium also occurs in more than 140 other minerals, including the commercially useful ores baddeleyite and kosnarite.^[16]

7911 °F)

Density near r.t. 6.52 g/cm³

when liquid, at m.p. 5.8 g/cm³

Heat of fusion 14 kJ/mol

Heat of vaporization 591 kJ/mol

Molar heat capacity 25.36 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	2639	2891	3197	3575	4053	4678

Atomic properties

Oxidation states 4, 3, 2, 1, −2^[2] (an amphoteric oxide)

Electronegativity Pauling scale: 1.33

Ionization energies
1st: 640.1 kJ/mol
2nd: 1270 kJ/mol
3rd: 2218 kJ/mol

Atomic radius empirical: 160 pm

Covalent radius 175±7 pm

Miscellanea

Crystal structure hexagonal close-packed (hcp)



Speed of sound 3800 m/s (at 20 °C)
thin rod

Thermal expansion 5.7 µm/(m·K) (at 25 °C)

Thermal conductivity 22.6 W/(m·K)

Electrical resistivity 421 nΩ·m (at 20 °C)

Zirconium is relatively abundant in S-type stars, and it has been detected in the sun and in meteorites. Lunar rock samples brought back from several Apollo missions to the moon have a high zirconium oxide content relative to terrestrial rocks.^[8]

External links

- Chemistry in its element podcast (<http://www.rsc.org/chemistryworld/podcast/element.asp>) (MP3) from the Royal Society of Chemistry's Chemistry World: Zirconium (http://www.rsc.org/images/CIIE_zirconium_remix2_48k_tcm18-117340.mp3)
- Zirconium (<http://www.periodicvideos.com/videos/040.htm>) at *The Periodic Table of Videos* (University of Nottingham)

Magnetic ordering	paramagnetic ^[3]
Young's modulus	88 GPa
Shear modulus	33 GPa
Bulk modulus	91.1 GPa
Poisson ratio	0.34
Mohs hardness	5.0
Vickers hardness	820–1800 MPa
Brinell hardness	638–1880 MPa
CAS Number	7440-67-7

History

Naming	after <i>zircon</i> , <i>zargun</i> زرگون meaning "gold-colored".
Discovery	Martin Heinrich Klaproth (1789)
First isolation	Jöns Jakob Berzelius (1824)

Most stable isotopes of zirconium

iso	NA	half-life	DM	DE (MeV)	DP
88Zr	syn	83.4 d	ε	-	88Y
			γ	0.392D	-
89Zr	syn	78.4 h	ε	-	89Y
			β+	0.902	89Y
			γ	0.909D	-
90Zr	51.45%	is stable with 50 neutrons			
91Zr	11.22%	is stable with 51 neutrons			
92Zr	17.15%	is stable with 52 neutrons			
93Zr	trace	1.53×10 ⁶ y	β ⁻	0.060	⁹³ Nb
94Zr	17.38%	is stable with 54 neutrons			
96Zr	2.80%	2.0×10 ¹⁹ y ^[4]	β ⁻ β ⁻	3.348	⁹⁶ Mo