

# 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".<sup>[5]</sup> 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.<sup>[6][7]</sup> 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.<sup>[8]</sup> However, it will dissolve in hydrochloric and sulfuric acid, especially when fluorine is present.<sup>[9]</sup> Alloys with zinc are magnetic at less than 35 K.<sup>[8]</sup>

The melting point of zirconium is 1855 °C (3371 °F), and the boiling point is 4371 °C (7900 °F).<sup>[8]</sup> 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.<sup>[10]</sup>

At room temperature zirconium exhibits a hexagonally close packed crystal structure,  $\alpha$ -Zr, which changes to  $\beta$ -Zr a body-centered cubic crystal structure at 863 °C. Zirconium exists in the  $\beta$ -phase until the melting point.<sup>[11]</sup>

## Isotopes

### Zirconium, $_{40}\text{Zr}$



#### General properties

<b>Name, symbol</b>	zirconium, Zr
<b>Appearance</b>	silvery white

#### Zirconium in the periodic table

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

#### Physical properties

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




Naturally occurring zirconium is composed of five isotopes. <sup>90</sup>Zr, <sup>91</sup>Zr, <sup>92</sup>Zr and <sup>94</sup>Zr are stable, although <sup>94</sup>Zr is predicted to undergo double beta decay (not observed experimentally) with a half-life of more than 1.10×10<sup>17</sup> years. <sup>96</sup>Zr has a half-life of 2.4×10<sup>19</sup> years, and is the longest-lived radioisotope of zirconium. Of these natural isotopes, <sup>90</sup>Zr is the most common, making up 51.45% of all zirconium. <sup>96</sup>Zr is the least common, comprising only 2.80% of zirconium.<sup>[12]</sup>

Twenty-eight artificial isotopes of zirconium have been synthesized, ranging in atomic mass from 78 to 110. <sup>93</sup>Zr is the longest-lived artificial isotope, with a half-life of 1.53×10<sup>6</sup> years. <sup>110</sup>Zr, 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 <sup>88</sup>Zr, which decays by electron capture.<sup>[12]</sup>

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

## Occurrence

Zirconium has a concentration of about 130 mg/kg within the Earth's crust and about 0.026 µg/L in sea water.<sup>[13]</sup> 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 (ZrSiO<sub>4</sub>), a silicate mineral,<sup>[6]</sup> which is found primarily in Australia, Brazil, India, Russia, South Africa and the United States, as well as in smaller deposits around the world.<sup>[7]</sup> As of 2013, two-thirds of zircon mining occurs in Australia and South Africa.<sup>[14]</sup> Zircon resources exceed 60 million tonnes worldwide<sup>[15]</sup> and annual worldwide zirconium production is approximately 900,000 tonnes.<sup>[13]</sup> Zirconium also occurs in more than 140 other minerals, including the commercially useful ores baddeleyite and kosnarite.<sup>[16]</sup>

	7911 °F)					
<b>Density</b> near r.t.	6.52 g/cm <sup>3</sup>					
when liquid, at m.p.	5.8 g/cm <sup>3</sup>					
<b>Heat of fusion</b>	14 kJ/mol					
<b>Heat of vaporization</b>	591 kJ/mol					
<b>Molar heat capacity</b>	25.36 J/(mol·K)					
<b>Vapor pressure</b>						
<b>P (Pa)</b>	<b>1</b>	<b>10</b>	<b>100</b>	<b>1 k</b>	<b>10 k</b>	<b>100 k</b>
<b>at T (K)</b>	2639	2891	3197	3575	4053	4678
<b>Atomic properties</b>						
<b>Oxidation states</b>	<b>4, 3, 2, 1, −2</b> <sup>[2]</sup> (an amphoteric oxide)					
<b>Electronegativity</b>	Pauling scale: 1.33					
<b>Ionization energies</b>	1st: 640.1 kJ/mol 2nd: 1270 kJ/mol 3rd: 2218 kJ/mol					
<b>Atomic radius</b>	empirical: 160 pm					
<b>Covalent radius</b>	175±7 pm					
<b>Miscellanea</b>						
<b>Crystal structure</b>	hexagonal close-packed (hcp)					
						
<b>Speed of sound</b> thin rod	3800 m/s (at 20 °C)					
<b>Thermal expansion</b>	5.7 μm/(m·K) (at 25 °C)					
<b>Thermal conductivity</b>	22.6 W/(m·K)					
<b>Electrical resistivity</b>	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.<sup>[8]</sup>

## 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](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)

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

### History

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

### Most stable isotopes of zirconium



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