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**Zirconium**

From Wikipedia, the free encyclopedia

[Jump to navigation](https://en.wikipedia.org/wiki/Zirconium#mw-head) [Jump to search](https://en.wikipedia.org/wiki/Zirconium#p-search)

Not to be confused with [zircon](https://en.wikipedia.org/wiki/Zircon), [zirconia](https://en.wikipedia.org/wiki/Zirconia), or [cubic zirconia](https://en.wikipedia.org/wiki/Cubic_zirconia).

"Zr" redirects here. For other uses, see [ZR (disambiguation)](https://en.wikipedia.org/wiki/ZR_(disambiguation)).

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| --- | --- |
| Zirconium,  40Zr | |
| [Zirconium crystal bar and 1cm3 cube.jpg](https://en.wikipedia.org/wiki/File:Zirconium_crystal_bar_and_1cm3_cube.jpg) | |
| **General properties** | |
| **Pronunciation** | [/zərˈkoʊniəm/](https://en.wikipedia.org/wiki/Help:IPA/English) ​([*zər-KOH-nee-əm*](https://en.wikipedia.org/wiki/Help:Pronunciation_respelling_key)) |
| **Appearance** | silvery white |
| [**Standard atomic weight**](https://en.wikipedia.org/wiki/Standard_atomic_weight) **(*A*r, standard)** | 91.224(2)[[1]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CIAAW2016-1) |
| **Zirconium in the** [**periodic table**](https://en.wikipedia.org/wiki/Periodic_table) | |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 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[Neon](https://en.wikipedia.org/wiki/Neon) | | [Sodium](https://en.wikipedia.org/wiki/Sodium) | [Magnesium](https://en.wikipedia.org/wiki/Magnesium) |  | | | | | | | | | | | | | | | | | | | | | | | | [Aluminium](https://en.wikipedia.org/wiki/Aluminium) | [Silicon](https://en.wikipedia.org/wiki/Silicon) | [Phosphorus](https://en.wikipedia.org/wiki/Phosphorus) | [Sulfur](https://en.wikipedia.org/wiki/Sulfur) | [Chlorine](https://en.wikipedia.org/wiki/Chlorine) | [Argon](https://en.wikipedia.org/wiki/Argon) | | [Potassium](https://en.wikipedia.org/wiki/Potassium) | [Calcium](https://en.wikipedia.org/wiki/Calcium) | [Scandium](https://en.wikipedia.org/wiki/Scandium) |  | | | | | | | | | | | | | | [Titanium](https://en.wikipedia.org/wiki/Titanium) | [Vanadium](https://en.wikipedia.org/wiki/Vanadium) | [Chromium](https://en.wikipedia.org/wiki/Chromium) | [Manganese](https://en.wikipedia.org/wiki/Manganese) | [Iron](https://en.wikipedia.org/wiki/Iron) | [Cobalt](https://en.wikipedia.org/wiki/Cobalt) | [Nickel](https://en.wikipedia.org/wiki/Nickel) | [Copper](https://en.wikipedia.org/wiki/Copper) | [Zinc](https://en.wikipedia.org/wiki/Zinc) | [Gallium](https://en.wikipedia.org/wiki/Gallium) | [Germanium](https://en.wikipedia.org/wiki/Germanium) | [Arsenic](https://en.wikipedia.org/wiki/Arsenic) | [Selenium](https://en.wikipedia.org/wiki/Selenium) | [Bromine](https://en.wikipedia.org/wiki/Bromine) | [Krypton](https://en.wikipedia.org/wiki/Krypton) | | [Rubidium](https://en.wikipedia.org/wiki/Rubidium) | [Strontium](https://en.wikipedia.org/wiki/Strontium) | [Yttrium](https://en.wikipedia.org/wiki/Yttrium) |  |  | | | | | | | | | | | | | Zirconium | [Niobium](https://en.wikipedia.org/wiki/Niobium) | [Molybdenum](https://en.wikipedia.org/wiki/Molybdenum) | [Technetium](https://en.wikipedia.org/wiki/Technetium) | [Ruthenium](https://en.wikipedia.org/wiki/Ruthenium) | [Rhodium](https://en.wikipedia.org/wiki/Rhodium) | [Palladium](https://en.wikipedia.org/wiki/Palladium) | [Silver](https://en.wikipedia.org/wiki/Silver) | [Cadmium](https://en.wikipedia.org/wiki/Cadmium) | [Indium](https://en.wikipedia.org/wiki/Indium) | [Tin](https://en.wikipedia.org/wiki/Tin) | [Antimony](https://en.wikipedia.org/wiki/Antimony) | [Tellurium](https://en.wikipedia.org/wiki/Tellurium) | [Iodine](https://en.wikipedia.org/wiki/Iodine) | [Xenon](https://en.wikipedia.org/wiki/Xenon) | | [Caesium](https://en.wikipedia.org/wiki/Caesium) | [Barium](https://en.wikipedia.org/wiki/Barium) | [Lanthanum](https://en.wikipedia.org/wiki/Lanthanum) | [Cerium](https://en.wikipedia.org/wiki/Cerium) | [Praseodymium](https://en.wikipedia.org/wiki/Praseodymium) | [Neodymium](https://en.wikipedia.org/wiki/Neodymium) | [Promethium](https://en.wikipedia.org/wiki/Promethium) | [Samarium](https://en.wikipedia.org/wiki/Samarium) | [Europium](https://en.wikipedia.org/wiki/Europium) | [Gadolinium](https://en.wikipedia.org/wiki/Gadolinium) | [Terbium](https://en.wikipedia.org/wiki/Terbium) | [Dysprosium](https://en.wikipedia.org/wiki/Dysprosium) | [Holmium](https://en.wikipedia.org/wiki/Holmium) | [Erbium](https://en.wikipedia.org/wiki/Erbium) | [Thulium](https://en.wikipedia.org/wiki/Thulium) | [Ytterbium](https://en.wikipedia.org/wiki/Ytterbium) | [Lutetium](https://en.wikipedia.org/wiki/Lutetium) | [Hafnium](https://en.wikipedia.org/wiki/Hafnium) | [Tantalum](https://en.wikipedia.org/wiki/Tantalum) | [Tungsten](https://en.wikipedia.org/wiki/Tungsten) | [Rhenium](https://en.wikipedia.org/wiki/Rhenium) | [Osmium](https://en.wikipedia.org/wiki/Osmium) | [Iridium](https://en.wikipedia.org/wiki/Iridium) | [Platinum](https://en.wikipedia.org/wiki/Platinum) | [Gold](https://en.wikipedia.org/wiki/Gold) | [Mercury (element)](https://en.wikipedia.org/wiki/Mercury_(element)) | [Thallium](https://en.wikipedia.org/wiki/Thallium) | [Lead](https://en.wikipedia.org/wiki/Lead) | [Bismuth](https://en.wikipedia.org/wiki/Bismuth) | [Polonium](https://en.wikipedia.org/wiki/Polonium) | [Astatine](https://en.wikipedia.org/wiki/Astatine) | [Radon](https://en.wikipedia.org/wiki/Radon) | | [Francium](https://en.wikipedia.org/wiki/Francium) | [Radium](https://en.wikipedia.org/wiki/Radium) | [Actinium](https://en.wikipedia.org/wiki/Actinium) | [Thorium](https://en.wikipedia.org/wiki/Thorium) | [Protactinium](https://en.wikipedia.org/wiki/Protactinium) | [Uranium](https://en.wikipedia.org/wiki/Uranium) | [Neptunium](https://en.wikipedia.org/wiki/Neptunium) | [Plutonium](https://en.wikipedia.org/wiki/Plutonium) | [Americium](https://en.wikipedia.org/wiki/Americium) | [Curium](https://en.wikipedia.org/wiki/Curium) | [Berkelium](https://en.wikipedia.org/wiki/Berkelium) | [Californium](https://en.wikipedia.org/wiki/Californium) | [Einsteinium](https://en.wikipedia.org/wiki/Einsteinium) | [Fermium](https://en.wikipedia.org/wiki/Fermium) | [Mendelevium](https://en.wikipedia.org/wiki/Mendelevium) | [Nobelium](https://en.wikipedia.org/wiki/Nobelium) | [Lawrencium](https://en.wikipedia.org/wiki/Lawrencium) | [Rutherfordium](https://en.wikipedia.org/wiki/Rutherfordium) | [Dubnium](https://en.wikipedia.org/wiki/Dubnium) | [Seaborgium](https://en.wikipedia.org/wiki/Seaborgium) | [Bohrium](https://en.wikipedia.org/wiki/Bohrium) | [Hassium](https://en.wikipedia.org/wiki/Hassium) | [Meitnerium](https://en.wikipedia.org/wiki/Meitnerium) | [Darmstadtium](https://en.wikipedia.org/wiki/Darmstadtium) | [Roentgenium](https://en.wikipedia.org/wiki/Roentgenium) | [Copernicium](https://en.wikipedia.org/wiki/Copernicium) | [Nihonium](https://en.wikipedia.org/wiki/Nihonium) | [Flerovium](https://en.wikipedia.org/wiki/Flerovium) | [Moscovium](https://en.wikipedia.org/wiki/Moscovium) | [Livermorium](https://en.wikipedia.org/wiki/Livermorium) | [Tennessine](https://en.wikipedia.org/wiki/Tennessine) | [Oganesson](https://en.wikipedia.org/wiki/Oganesson) | | [Ti](https://en.wikipedia.org/wiki/Titanium) ↑ **Zr** ↓ [Hf](https://en.wikipedia.org/wiki/Hafnium) | | [yttrium](https://en.wikipedia.org/wiki/Yttrium) ← **zirconium** → [niobium](https://en.wikipedia.org/wiki/Niobium) | | | | |
| [**Atomic number**](https://en.wikipedia.org/wiki/Atomic_number)(*Z*) | 40 |
| [**Group**](https://en.wikipedia.org/wiki/Group_(periodic_table)) | [group 4](https://en.wikipedia.org/wiki/Group_4_element) |
| [**Period**](https://en.wikipedia.org/wiki/Period_(periodic_table)) | [period 5](https://en.wikipedia.org/wiki/Period_(periodic_table)#Period_5) |
| [**Block**](https://en.wikipedia.org/wiki/Block_(periodic_table)) | [d-block](https://en.wikipedia.org/wiki/D-block) |
| [**Element category**](https://en.wikipedia.org/wiki/Names_for_sets_of_chemical_elements#Category) | [transition metal](https://en.wikipedia.org/wiki/Transition_metal) |
| [**Electron configuration**](https://en.wikipedia.org/wiki/Electron_configuration) | [[Kr](https://en.wikipedia.org/wiki/Krypton)] 4d2 5s2 |
| Electrons per shell | 2, 8, 18, 10, 2 |
| **Physical properties** | |
| [**Phase**](https://en.wikipedia.org/wiki/Phase_(matter)) **at**[**STP**](https://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure) | [solid](https://en.wikipedia.org/wiki/Solid) |
| [**Melting point**](https://en.wikipedia.org/wiki/Melting_point) | 2128 [K](https://en.wikipedia.org/wiki/Kelvin) ​(1855 °C, ​3371 °F) |
| [**Boiling point**](https://en.wikipedia.org/wiki/Boiling_point) | 4650 K ​(4377 °C, ​7911 °F) |
| [**Density**](https://en.wikipedia.org/wiki/Density)(near r.t.) | 6.52 g/cm3 |
| when liquid (at m.p.) | 5.8 g/cm3 |
| [**Heat of fusion**](https://en.wikipedia.org/wiki/Enthalpy_of_fusion) | 14 [kJ/mol](https://en.wikipedia.org/wiki/Kilojoule_per_mole) |
| [**Heat of vaporization**](https://en.wikipedia.org/wiki/Enthalpy_of_vaporization) | 591 kJ/mol |
| [**Molar heat capacity**](https://en.wikipedia.org/wiki/Molar_heat_capacity) | 25.36 J/(mol·K) |
| [**Vapor pressure**](https://en.wikipedia.org/wiki/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**](https://en.wikipedia.org/wiki/Oxidation_state) | −2, +1,[[2]](https://en.wikipedia.org/wiki/Zirconium#cite_note-2) +2, +3, **+4** (an [amphoteric](https://en.wikipedia.org/wiki/Amphoterism) oxide) |
| [**Electronegativity**](https://en.wikipedia.org/wiki/Electronegativity) | Pauling scale: 1.33 |
| [**Ionization energies**](https://en.wikipedia.org/wiki/Ionization_energy) | * 1st: 640.1 kJ/mol * 2nd: 1270 kJ/mol * 3rd: 2218 kJ/mol |
| [**Atomic radius**](https://en.wikipedia.org/wiki/Atomic_radius) | empirical: 160 [pm](https://en.wikipedia.org/wiki/Picometre) |
| [**Covalent radius**](https://en.wikipedia.org/wiki/Covalent_radius) | 175±7 pm |
| [Color lines in a spectral range](https://en.wikipedia.org/wiki/File:Zirconium_spectrum_visible.png)  [**Spectral lines**](https://en.wikipedia.org/wiki/Spectral_line) **of zirconium** | |
| **Other properties** | |
| [**Crystal structure**](https://en.wikipedia.org/wiki/Crystal_structure) | ​[hexagonal close-packed](https://en.wikipedia.org/wiki/Close-packing_of_equal_spheres) (hcp)  [Hexagonal close-packed crystal structure for zirconium](https://en.wikipedia.org/wiki/File:Hexagonal_close_packed.svg) |
| [**Speed of sound**](https://en.wikipedia.org/wiki/Speed_of_sound)thin rod | 3800 m/s (at 20 °C) |
| [**Thermal expansion**](https://en.wikipedia.org/wiki/Coefficient_of_thermal_expansion) | 5.7 µm/(m·K) (at 25 °C) |
| [**Thermal conductivity**](https://en.wikipedia.org/wiki/Thermal_conductivity) | 22.6 W/(m·K) |
| [**Electrical resistivity**](https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity) | 421 nΩ·m (at 20 °C) |
| [**Magnetic ordering**](https://en.wikipedia.org/wiki/Magnetism) | [paramagnetic](https://en.wikipedia.org/wiki/Paramagnetic)[[3]](https://en.wikipedia.org/wiki/Zirconium#cite_note-magnet-3) |
| [**Young's modulus**](https://en.wikipedia.org/wiki/Young%27s_modulus) | 88 GPa |
| [**Shear modulus**](https://en.wikipedia.org/wiki/Shear_modulus) | 33 GPa |
| [**Bulk modulus**](https://en.wikipedia.org/wiki/Bulk_modulus) | 91.1 GPa |
| [**Poisson ratio**](https://en.wikipedia.org/wiki/Poisson%27s_ratio) | 0.34 |
| [**Mohs hardness**](https://en.wikipedia.org/wiki/Mohs_scale_of_mineral_hardness) | 5.0 |
| [**Vickers hardness**](https://en.wikipedia.org/wiki/Vickers_hardness_test) | 820–1800 MPa |
| [**Brinell hardness**](https://en.wikipedia.org/wiki/Brinell_hardness_test) | 638–1880 MPa |
| [**CAS Number**](https://en.wikipedia.org/wiki/CAS_Registry_Number) | 7440-67-7 |
| **History** | |
| **Naming** | after *zircon*, *zargun* زرگون meaning "gold-colored". |
| [**Discovery**](https://en.wikipedia.org/wiki/Timeline_of_chemical_element_discoveries) | [Martin Heinrich Klaproth](https://en.wikipedia.org/wiki/Martin_Heinrich_Klaproth) (1789) |
| **First isolation** | [Jöns Jakob Berzelius](https://en.wikipedia.org/wiki/J%C3%B6ns_Jakob_Berzelius) (1824) |
| **Main** [**isotopes of zirconium**](https://en.wikipedia.org/wiki/Isotopes_of_zirconium) | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | [**Iso­tope**](https://en.wikipedia.org/wiki/Isotope) | [**Abun­dance**](https://en.wikipedia.org/wiki/Natural_abundance) | [**Half-life**](https://en.wikipedia.org/wiki/Half-life) **(*t*1/2)** | [**Decay mode**](https://en.wikipedia.org/wiki/Radioactive_decay) | [**Pro­duct**](https://en.wikipedia.org/wiki/Decay_product) | | **88Zr** | [syn](https://en.wikipedia.org/wiki/Synthetic_radioisotope) | 83.4 d | [ε](https://en.wikipedia.org/wiki/Electron_capture) | [88Y](https://en.wikipedia.org/wiki/Yttrium-88) | | [γ](https://en.wikipedia.org/wiki/Gamma_radiation) | – | | **89Zr** | syn | 78.4 h | ε | [89Y](https://en.wikipedia.org/wiki/Yttrium-89) | | [β+](https://en.wikipedia.org/wiki/Positron_emission) | 89Y | | γ | – | | **90Zr** | 51.45% | [stable](https://en.wikipedia.org/wiki/Stable_isotope) | | | | **91Zr** | 11.22% | stable | | | | **92Zr** | 17.15% | stable | | | | **93Zr** | [trace](https://en.wikipedia.org/wiki/Trace_radioisotope) | 1.53×106 y | [β−](https://en.wikipedia.org/wiki/Beta_emission) | [93Nb](https://en.wikipedia.org/wiki/Niobium-93) | | **94Zr** | 17.38% | stable | | | | [**96Zr**](https://en.wikipedia.org/wiki/Molybdenum-96) | 2.80% | 2.0×1019 y[[4]](https://en.wikipedia.org/wiki/Zirconium#cite_note-4) | [β−β−](https://en.wikipedia.org/wiki/Double_beta_decay) | 96Mo | | |
| * [view](https://en.wikipedia.org/wiki/Template:Infobox_zirconium) * [talk](https://en.wikipedia.org/wiki/Template_talk:Infobox_zirconium) * [edit](https://en.wikipedia.org/w/index.php?title=Template:Infobox_zirconium&action=edit)   | [references](https://en.wikipedia.org/wiki/List_of_data_references_for_chemical_elements) | |

**Zirconium** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Zr** and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 40. The name *zirconium* is taken from the name of the mineral [zircon](https://en.wikipedia.org/wiki/Zircon) (the word is related to [Persian](https://en.wikipedia.org/wiki/Persian_Language) [*zargun*](https://en.wikipedia.org/wiki/Jargoon) (zircon;*zar-gun*, "gold-like" or "as gold")), the most important source of zirconium.[[6]](https://en.wikipedia.org/wiki/Zirconium#cite_note-6) It is a lustrous, grey-white, strong [transition metal](https://en.wikipedia.org/wiki/Transition_metal) that closely resembles [hafnium](https://en.wikipedia.org/wiki/Hafnium) and, to a lesser extent, [titanium](https://en.wikipedia.org/wiki/Titanium). Zirconium is mainly used as a [refractory](https://en.wikipedia.org/wiki/Refractory) and [opacifier](https://en.wikipedia.org/wiki/Opacifier), although small amounts are used as an alloying agent for its strong resistance to corrosion. Zirconium forms a variety of [inorganic](https://en.wikipedia.org/wiki/Inorganic_chemistry) and [organometallic compounds](https://en.wikipedia.org/wiki/Organometallic_compounds) such as [zirconium dioxide](https://en.wikipedia.org/wiki/Zirconium_dioxide) and [zirconocene dichloride](https://en.wikipedia.org/wiki/Zirconocene_dichloride), respectively. Five [isotopes](https://en.wikipedia.org/wiki/Isotope) occur naturally, three of which are stable. Zirconium compounds have no known biological role.



**Contents**

* [1 Characteristics](https://en.wikipedia.org/wiki/Zirconium#Characteristics)
  + [1.1 Isotopes](https://en.wikipedia.org/wiki/Zirconium#Isotopes)
  + [1.2 Occurrence](https://en.wikipedia.org/wiki/Zirconium#Occurrence)
* [2 Production](https://en.wikipedia.org/wiki/Zirconium#Production)
  + [2.1 Separation of zirconium and hafnium](https://en.wikipedia.org/wiki/Zirconium#Separation_of_zirconium_and_hafnium)
* [3 Compounds](https://en.wikipedia.org/wiki/Zirconium#Compounds)
  + [3.1 Oxides, nitrides, and carbides](https://en.wikipedia.org/wiki/Zirconium#Oxides,_nitrides,_and_carbides)
  + [3.2 Halides and pseudohalides](https://en.wikipedia.org/wiki/Zirconium#Halides_and_pseudohalides)
  + [3.3 Organic derivatives](https://en.wikipedia.org/wiki/Zirconium#Organic_derivatives)
* [4 History](https://en.wikipedia.org/wiki/Zirconium#History)
* [5 Applications](https://en.wikipedia.org/wiki/Zirconium#Applications)
  + [5.1 Compounds](https://en.wikipedia.org/wiki/Zirconium#Compounds_2)
  + [5.2 Metal](https://en.wikipedia.org/wiki/Zirconium#Metal)
    - [5.2.1 Nuclear applications](https://en.wikipedia.org/wiki/Zirconium#Nuclear_applications)
    - [5.2.2 Space and aeronautic industries](https://en.wikipedia.org/wiki/Zirconium#Space_and_aeronautic_industries)
  + [5.3 Positron emission tomography cameras](https://en.wikipedia.org/wiki/Zirconium#Positron_emission_tomography_cameras)
  + [5.4 Biomedical applications](https://en.wikipedia.org/wiki/Zirconium#Biomedical_applications)
  + [5.5 Defunct applications](https://en.wikipedia.org/wiki/Zirconium#Defunct_applications)
* [6 Safety](https://en.wikipedia.org/wiki/Zirconium#Safety)
* [7 See also](https://en.wikipedia.org/wiki/Zirconium#See_also)
* [8 References](https://en.wikipedia.org/wiki/Zirconium#References)
* [9 External links](https://en.wikipedia.org/wiki/Zirconium#External_links)

**Characteristics**

[](https://en.wikipedia.org/wiki/File:Zirconium_rod.jpg)

Zirconium rod

Zirconium is a [lustrous](https://en.wikipedia.org/wiki/Luster_(mineralogy)), greyish-white, soft, [ductile](https://en.wikipedia.org/wiki/Ductile), [malleable](https://en.wikipedia.org/wiki/Malleable) metal that is solid at room temperature, though it is hard and [brittle](https://en.wikipedia.org/wiki/Brittle) at lesser purities.[[7]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nbb-7)[[8]](https://en.wikipedia.org/wiki/Zirconium#cite_note-madehow-8) 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.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) However, it will dissolve in [hydrochloric](https://en.wikipedia.org/wiki/Hydrochloric_acid) and [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid), especially when [fluorine](https://en.wikipedia.org/wiki/Fluorine) is present.[[10]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Nostrand-10) [Alloys](https://en.wikipedia.org/wiki/Alloy) with [zinc](https://en.wikipedia.org/wiki/Zinc) are [magnetic](https://en.wikipedia.org/wiki/Magnetism) at less than 35 K.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9)

The [melting point](https://en.wikipedia.org/wiki/Melting_point) of zirconium is 1855 °C (3371 °F), and the [boiling point](https://en.wikipedia.org/wiki/Boiling_point) is 4371 °C (7900 °F).[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) Zirconium has an [electronegativity](https://en.wikipedia.org/wiki/Electronegativity) of 1.33 on the Pauling scale. Of the elements within the [d-block](https://en.wikipedia.org/wiki/D-block) with known electronegativities, zirconium has the fifth lowest electronegativity after [hafnium](https://en.wikipedia.org/wiki/Hafnium), [yttrium](https://en.wikipedia.org/wiki/Yttrium), [lanthanum](https://en.wikipedia.org/wiki/Lanthanum), and [actinium](https://en.wikipedia.org/wiki/Actinium).[[11]](https://en.wikipedia.org/wiki/Zirconium#cite_note-11)

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.[[12]](https://en.wikipedia.org/wiki/Zirconium#cite_note-12)

**Isotopes**

Main article: [Isotopes of zirconium](https://en.wikipedia.org/wiki/Isotopes_of_zirconium)

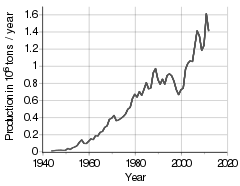
Naturally occurring zirconium is composed of five isotopes. 90Zr, 91Zr, 92Zr and 94Zr are stable, although 94Zr is predicted to undergo [double beta decay](https://en.wikipedia.org/wiki/Double_beta_decay) (not observed experimentally) with a [half-life](https://en.wikipedia.org/wiki/Half-life) of more 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.[[13]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nubase-13)

Twenty-eight artificial isotopes of zirconium have been synthesized, ranging in atomic mass from 78 to 110. [93Zr](https://en.wikipedia.org/wiki/Zirconium-93) 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](https://en.wikipedia.org/wiki/Beta_decay), whereas those at or below 89 decay by [positron emission](https://en.wikipedia.org/wiki/Beta_decay). The only exception is 88Zr, which decays by [electron capture](https://en.wikipedia.org/wiki/Electron_capture).[[13]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nubase-13)

Five isotopes of zirconium also exist as [metastable isomers](https://en.wikipedia.org/wiki/Nuclear_isomer): 83mZr, 85mZr, 89mZr, 90m1Zr, 90m2Zr and 91mZr. Of these, 90m2Zr has the shortest half-life at 131 nanoseconds. 89mZr is the longest lived with a half-life of 4.161 minutes.[[13]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nubase-13)

**Occurrence**

See also: [Category:Zirconium minerals](https://en.wikipedia.org/wiki/Category:Zirconium_minerals).

[](https://en.wikipedia.org/wiki/File:Zirconium_mineral_concentrates_-_world_production_trend.svg)

World production trend of zirconium mineral concentrates

Zirconium has a concentration of about 130 mg/kg within the [Earth's crust](https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust) and about 0.026 μg/L in [sea water](https://en.wikipedia.org/wiki/Sea_water).[[14]](https://en.wikipedia.org/wiki/Zirconium#cite_note-argonne-14) It is not found in nature as a [native metal](https://en.wikipedia.org/wiki/Native_metal), reflecting its intrinsic instability with respect to water. The principal commercial source of zirconium is [zircon](https://en.wikipedia.org/wiki/Zircon) (ZrSiO4), a [silicate mineral](https://en.wikipedia.org/wiki/Silicate_mineral),[[7]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nbb-7) which is found primarily in Australia, Brazil, India, Russia, South Africa and the United States, as well as in smaller deposits around the world.[[8]](https://en.wikipedia.org/wiki/Zirconium#cite_note-madehow-8) As of 2013, two-thirds of zircon mining occurs in Australia and South Africa.[[15]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nbb13-15) Zircon resources exceed 60 million [tonnes](https://en.wikipedia.org/wiki/Tonne) worldwide[[16]](https://en.wikipedia.org/wiki/Zirconium#cite_note-usgs2008-16) and annual worldwide zirconium production is approximately 900,000 tonnes.[[14]](https://en.wikipedia.org/wiki/Zirconium#cite_note-argonne-14) Zirconium also occurs in more than 140 other minerals, including the commercially useful ores [baddeleyite](https://en.wikipedia.org/wiki/Baddeleyite) and [kosnarite](https://en.wikipedia.org/w/index.php?title=Kosnarite&action=edit&redlink=1).[[17]](https://en.wikipedia.org/wiki/Zirconium#cite_note-17)

Zirconium is relatively abundant in [S-type stars](https://en.wikipedia.org/wiki/Stellar_classification#Class_S), and it has been detected in the sun and in meteorites. Lunar rock samples brought back from several [Apollo](https://en.wikipedia.org/wiki/Apollo_program) missions to the moon have a high zirconium oxide content relative to terrestrial rocks.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9)

**Production**

[](https://en.wikipedia.org/wiki/File:2005zirconium.PNG)

Zirconium output in 2005

Zirconium is a by-product of the mining and processing of the [titanium](https://en.wikipedia.org/wiki/Titanium) minerals [ilmenite](https://en.wikipedia.org/wiki/Ilmenite) and [rutile](https://en.wikipedia.org/wiki/Rutile), as well as [tin](https://en.wikipedia.org/wiki/Tin) mining.[[18]](https://en.wikipedia.org/wiki/Zirconium#cite_note-18) From 2003 to 2007, while prices for the mineral zircon steadily increased from $360 to $840 per tonne, the price for unwrought zirconium metal decreased from $39,900 to $22,700 per ton. Zirconium metal is much higher priced than zircon because the reduction processes are expensive.[[16]](https://en.wikipedia.org/wiki/Zirconium#cite_note-usgs2008-16)

Collected from coastal waters, zircon-bearing sand is purified by [spiral concentrators](https://en.wikipedia.org/wiki/Spiral_separator#Wet_Spiral_Separators) to remove lighter materials, which are then returned to the water because they are natural components of beach sand. Using [magnetic separation](https://en.wikipedia.org/wiki/Magnetic_separation), the titanium ores [ilmenite](https://en.wikipedia.org/wiki/Ilmenite) and [rutile](https://en.wikipedia.org/wiki/Rutile) are removed.

Most zircon is used directly in commercial applications, but a small percentage is converted to the metal. Most Zr metal is produced by the reduction of the [zirconium(IV) chloride](https://en.wikipedia.org/wiki/Zirconium(IV)_chloride) with [magnesium](https://en.wikipedia.org/wiki/Magnesium) metal in the [Kroll process](https://en.wikipedia.org/wiki/Kroll_process).[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) The resulting metal is [sintered](https://en.wikipedia.org/wiki/Sintering) until sufficiently ductile for metalworking.[[8]](https://en.wikipedia.org/wiki/Zirconium#cite_note-madehow-8)

**Separation of zirconium and hafnium**

Commercial zirconium metal typically contains 1–3% of [hafnium](https://en.wikipedia.org/wiki/Hafnium),[[19]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Ullmann-19) which is usually not problematic because the chemical properties of hafnium and zirconium are very similar. Their neutron-absorbing properties differ strongly, however, necessitating the separation of hafnium from zirconium for nuclear reactors.[[20]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Stwertka-20) Several separation schemes are in use.[[19]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Ullmann-19) The [liquid-liquid extraction](https://en.wikipedia.org/wiki/Liquid-liquid_extraction) of the [thiocyanate](https://en.wikipedia.org/wiki/Thiocyanate)-oxide derivatives exploits the fact that the hafnium derivative is slightly more soluble in [methyl isobutyl ketone](https://en.wikipedia.org/wiki/Methyl_isobutyl_ketone) than in water. This method is used mainly in United States.

Zr and Hf can also be separated by [fractional crystallization](https://en.wikipedia.org/wiki/Fractional_crystallization_(chemistry)) of potassium hexafluorozirconate (K2ZrF6), which is less soluble in water than the analogous hafnium derivative.

[Fractional distillation](https://en.wikipedia.org/wiki/Fractional_distillation) of the tetrachlorides, also called [extractive distillation](https://en.wikipedia.org/wiki/Extractive_distillation), is used primarily in Europe.

The product of a quadruple VAM (vacuum arc melting) process, combined with hot extruding and different rolling applications is cured using high-pressure, high-temperature gas [autoclaving](https://en.wikipedia.org/wiki/Autoclave). This produces reactor-grade zirconium that is about 10 times more expensive than the hafnium-contaminated commercial grade.

Hafnium must be removed from zirconium for nuclear applications because hafnium has a neutron absorption cross-section 600 times greater than zirconium.[[21]](https://en.wikipedia.org/wiki/Zirconium#cite_note-b1-21) The separated hafnium can be used for reactor [control rods](https://en.wikipedia.org/wiki/Control_rods).[[22]](https://en.wikipedia.org/wiki/Zirconium#cite_note-22)

**Compounds**

See also: the categories [Zirconium compounds](https://en.wikipedia.org/wiki/Category:Zirconium_compounds) and [Zirconium minerals](https://en.wikipedia.org/wiki/Category:Zirconium_minerals).

Like other [transition metals](https://en.wikipedia.org/wiki/Transition_metal), zirconium forms a wide range of [inorganic compounds](https://en.wikipedia.org/wiki/Inorganic_chemistry) and [coordination complexes](https://en.wikipedia.org/wiki/Coordination_complex).[[23]](https://en.wikipedia.org/wiki/Zirconium#cite_note-23) In general, these compounds are colourless diamagnetic solids wherein zirconium has the [oxidation state](https://en.wikipedia.org/wiki/Oxidation_state) +4. Far fewer Zr(III) compounds are known, and Zr(II) is very rare.

**Oxides, nitrides, and carbides**

The most common oxide is [zirconium dioxide](https://en.wikipedia.org/wiki/Zirconium_dioxide), ZrO2, also known as *zirconia*. This clear to white-coloured solid has exceptional [fracture toughness](https://en.wikipedia.org/wiki/Fracture_toughness) and chemical resistance, especially in its [cubic](https://en.wikipedia.org/wiki/Cubic_zirconia) form.[[24]](https://en.wikipedia.org/wiki/Zirconium#cite_note-azomzirc-24) These properties make zirconia useful as a thermal barrier coating,[[25]](https://en.wikipedia.org/wiki/Zirconium#cite_note-25) although it is also a common [diamond](https://en.wikipedia.org/wiki/Diamond) substitute.[[24]](https://en.wikipedia.org/wiki/Zirconium#cite_note-azomzirc-24) Zirconium monoxide, ZrO, is also known and [S-type stars](https://en.wikipedia.org/wiki/S-type_star) are recognised by detection of its emission lines in the visual spectrum.[[26]](https://en.wikipedia.org/wiki/Zirconium#cite_note-26)

[Zirconium tungstate](https://en.wikipedia.org/wiki/Zirconium_tungstate) has the unusual property of shrinking in all dimensions when heated, whereas most other substances expand when heated.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) [Zirconyl chloride](https://en.wikipedia.org/wiki/Zirconyl_chloride) is a rare water-soluble zirconium complex with the relatively complicated formula [Zr4(OH)12(H2O)16]Cl8.

[Zirconium carbide](https://en.wikipedia.org/wiki/Zirconium_carbide) and [zirconium nitride](https://en.wikipedia.org/wiki/Zirconium_nitride) are refractory solids. The carbide is used for drilling tools and cutting edges. Zirconium hydride phases are also known.

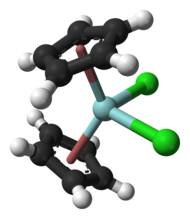
[Lead zirconate titanate](https://en.wikipedia.org/wiki/Lead_zirconate_titanate) (PZT) is the most commonly used piezoelectric material, with applications such as ultrasonic transducers, hydrophones, common rail injectors, piezoelectric transformers and micro-actuators.

**Halides and pseudohalides**

All four common halides are known, [ZrF4](https://en.wikipedia.org/wiki/Zirconium(IV)_fluoride), [ZrCl4](https://en.wikipedia.org/wiki/Zirconium(IV)_chloride), [ZrBr4](https://en.wikipedia.org/wiki/Zirconium(IV)_bromide), and [ZrI4](https://en.wikipedia.org/wiki/Zirconium(IV)_iodide). All have polymeric structures and are far less volatile than the corresponding monomeric titanium tetrahalides. All tend to [hydrolyse](https://en.wikipedia.org/wiki/Hydrolyse) to give the so-called oxyhalides and dioxides.

The corresponding tetra[alkoxides](https://en.wikipedia.org/wiki/Alkoxide) are also known. Unlike the halides, the alkoxides dissolve in nonpolar solvents. Dihydrogen hexafluorozirconate is used in the metal finishing industry as an etching agent to promote paint adhesion.[[27]](https://en.wikipedia.org/wiki/Zirconium#cite_note-27)

**Organic derivatives**

[](https://en.wikipedia.org/wiki/File:Zirconocene-dichloride-from-xtal-3D-balls.png)

Zirconocene dichloride, a representative [organozirconium compound](https://en.wikipedia.org/wiki/Organozirconium_compound)

[Organozirconium chemistry](https://en.wikipedia.org/wiki/Organozirconium_chemistry) is the study of compounds containing a [carbon](https://en.wikipedia.org/wiki/Carbon)-zirconium bond. The first such compound was zirconocene dibromide ((C5H5)2ZrBr2), reported in 1952 by Birmingham and [Wilkinson](https://en.wikipedia.org/wiki/Geoffrey_Wilkinson).[[28]](https://en.wikipedia.org/wiki/Zirconium#cite_note-28) [Schwartz's reagent](https://en.wikipedia.org/wiki/Schwartz%27s_reagent), prepared in 1970 by P. C. Wailes and H. Weigold,[[29]](https://en.wikipedia.org/wiki/Zirconium#cite_note-29) is a [metallocene](https://en.wikipedia.org/wiki/Metallocene) used in [organic synthesis](https://en.wikipedia.org/wiki/Organic_synthesis) for transformations of [alkenes](https://en.wikipedia.org/wiki/Alkenes) and [alkynes](https://en.wikipedia.org/wiki/Alkyne).[[30]](https://en.wikipedia.org/wiki/Zirconium#cite_note-hart-30)

Zirconium is also a component of some [Ziegler-Natta catalysts](https://en.wikipedia.org/wiki/Ziegler-Natta_catalyst), used to produce [polypropylene](https://en.wikipedia.org/wiki/Polypropylene). This application exploits the ability of zirconium to reversibly form bonds to carbon. Most complexes of Zr(II) are derivatives of zirconocene, one example being (C5Me5)2Zr(CO)2.

**History**

The zirconium-containing mineral zircon and related minerals ([jargoon](https://en.wikipedia.org/wiki/Jargoon), hyacinth, [jacinth](https://en.wikipedia.org/wiki/Jacinth), ligure) were mentioned in biblical writings.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9)[[20]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Stwertka-20) The mineral was not known to contain a new element until 1789,[[31]](https://en.wikipedia.org/wiki/Zirconium#cite_note-greenwood-31) when [Klaproth](https://en.wikipedia.org/wiki/Martin_Heinrich_Klaproth) analyzed a jargoon from the island of Ceylon (now Sri Lanka). He named the new element Zirkonerde (zirconia).[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) [Humphry Davy](https://en.wikipedia.org/wiki/Humphry_Davy) attempted to isolate this new element in 1808 through electrolysis, but failed.[[7]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nbb-7) Zirconium metal was first obtained in an impure form in 1824 by [Berzelius](https://en.wikipedia.org/wiki/J%C3%B6ns_Jakob_Berzelius) by heating a mixture of potassium and potassium zirconium fluoride in an iron tube.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9)

The [*crystal bar process*](https://en.wikipedia.org/wiki/Crystal_bar_process) (also known as the *Iodide Process*), discovered by [Anton Eduard van Arkel](https://en.wikipedia.org/wiki/Anton_Eduard_van_Arkel) and [Jan Hendrik de Boer](https://en.wikipedia.org/wiki/Jan_Hendrik_de_Boer) in 1925, was the first industrial process for the commercial production of metallic zirconium. It involves the formation and subsequent thermal decomposition of [zirconium tetraiodide](https://en.wikipedia.org/wiki/Zirconium_tetraiodide), and was superseded in 1945 by the much cheaper [Kroll process](https://en.wikipedia.org/wiki/Kroll_process) developed by [William Justin Kroll](https://en.wikipedia.org/wiki/William_Justin_Kroll), in which zirconium tetrachloride is reduced by magnesium:[[8]](https://en.wikipedia.org/wiki/Zirconium#cite_note-madehow-8)[[32]](https://en.wikipedia.org/wiki/Zirconium#cite_note-metal1998-32)

ZrCl4 + 2 Mg → Zr + 2 MgCl2

**Applications**

Approximately 900,000 tonnes of zirconium ores were mined in 1995, mostly as zircon.[[19]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Ullmann-19)

**Compounds**

Most zircon is used directly in high-temperature applications. This material is refractory, hard, and resistant to chemical attack. Because of these properties, zircon finds many applications, few of which are highly publicized. Its main use is as an opacifier, conferring a white, opaque appearance to ceramic materials. Because of its chemical resistance, zircon is also used in aggressive environments, such as moulds for molten metals.

[Zirconium dioxide](https://en.wikipedia.org/wiki/Zirconium_dioxide) (ZrO2) is used in laboratory crucibles, in metallurgical furnaces, and as a refractory material.[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) Because it is mechanically strong and flexible, it can be [sintered](https://en.wikipedia.org/wiki/Sintered) into [ceramic knives](https://en.wikipedia.org/wiki/Ceramic_knife) and other blades.[[33]](https://en.wikipedia.org/wiki/Zirconium#cite_note-kyo-33) Zircon (ZrSiO4) and the [cubic zirconia](https://en.wikipedia.org/wiki/Cubic_zirconia) (ZrO2) are cut into gemstones for use in jewelry.

Zirconia is a component in some [abrasives](https://en.wikipedia.org/wiki/Abrasive), such as grinding wheels and [sandpaper](https://en.wikipedia.org/wiki/Sandpaper).[[31]](https://en.wikipedia.org/wiki/Zirconium#cite_note-greenwood-31)

**Metal**

A small fraction of the zircon is converted to the metal, which finds various niche applications. Because of zirconium's excellent resistance to corrosion, it is often used as an alloying agent in materials that are exposed to aggressive environments, such as surgical appliances, light filaments, and watch cases. The high reactivity of zirconium with oxygen at high temperatures is exploited in some specialised applications such as explosive primers and as [getters](https://en.wikipedia.org/wiki/Getter) in [vacuum tubes](https://en.wikipedia.org/wiki/Vacuum_tube). The same property is (probably) the purpose of including Zr nano-particles as [pyrophoric](https://en.wikipedia.org/wiki/Pyrophoric) material in explosive weapons such as the [BLU-97/B Combined Effects Bomb](https://en.wikipedia.org/wiki/BLU-97/B_Combined_Effects_Bomb). Burning zirconium was used as a light source in some [photographic flashbulbs](https://en.wikipedia.org/wiki/Flash_(photography)#Flashbulbs).

**Nuclear applications**

|  |  |
| --- | --- |
| [https://upload.wikimedia.org/wikipedia/en/thumb/9/99/Question_book-new.svg/50px-Question_book-new.svg.png](https://en.wikipedia.org/wiki/File:Question_book-new.svg) | This section **needs additional citations for** [**verification**](https://en.wikipedia.org/wiki/Wikipedia:Verifiability). Relevant discussion may be found on the [talk page](https://en.wikipedia.org/wiki/Talk:Zirconium#The_section_asserts_a_number_of_controversial_facts_that_should_be_readily_documented_if_they_are_true._Otherwise_-_?). Please help [improve this article](https://en.wikipedia.org/w/index.php?title=Zirconium&action=edit) by [adding citations to reliable sources](https://en.wikipedia.org/wiki/Help:Introduction_to_referencing_with_Wiki_Markup/1). Unsourced material may be challenged and removed. *(June 2016) (*[*Learn how and when to remove this template message*](https://en.wikipedia.org/wiki/Help:Maintenance_template_removal)*)* |

Cladding for nuclear reactor fuels consumes about 1% of the zirconium supply,[[19]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Ullmann-19) mainly in the form of [zircaloys](https://en.wikipedia.org/wiki/Zircaloy). The desired properties of these alloys are a low neutron-capture [cross-section](https://en.wikipedia.org/wiki/Neutron_cross-section) and resistance to corrosion under normal service conditions.[[8]](https://en.wikipedia.org/wiki/Zirconium#cite_note-madehow-8)[[9]](https://en.wikipedia.org/wiki/Zirconium#cite_note-CRC2008-9) Efficient methods for removing the hafnium impurities were developed to serve this purpose.

One disadvantage of zirconium alloys is that zirconium reacts with water at high temperatures, producing [hydrogen](https://en.wikipedia.org/wiki/Hydrogen) gas and accelerated degradation of the [fuel rod cladding](https://en.wikipedia.org/wiki/Nuclear_fuel#Common_physical_forms_of_nuclear_fuel):

Zr + 2 H2O → ZrO2 + 2 H2

This [exothermic](https://en.wikipedia.org/wiki/Exothermic) reaction is very slow below 100 °C, but at temperature above 900 °C the reaction is rapid. Most metals undergo similar reactions. The redox reaction is relevant to the instability of [fuel assemblies](https://en.wikipedia.org/wiki/Nuclear_fuel) at high temperatures.[[34]](https://en.wikipedia.org/wiki/Zirconium#cite_note-34) This reaction was responsible for a small hydrogen explosion first observed inside the reactor building of [Three Mile Island](https://en.wikipedia.org/wiki/Three_Mile_Island_accident) nuclear power plant in 1979, but at that time, the containment building was not damaged. The same reaction occurred in the reactors 1, 2 and 3 of the [Fukushima I Nuclear Power Plant](https://en.wikipedia.org/wiki/Fukushima_I_Nuclear_Power_Plant) (Japan) after the reactor cooling was interrupted by the [earthquake and tsunami](https://en.wikipedia.org/wiki/2011_T%C5%8Dhoku_earthquake_and_tsunami) disaster of March 11, 2011 leading to the [Fukushima I nuclear accidents](https://en.wikipedia.org/wiki/Fukushima_I_nuclear_accidents). After venting the hydrogen in the maintenance hall of those three reactors, the mixture of hydrogen with atmospheric [oxygen](https://en.wikipedia.org/wiki/Oxygen) exploded, severely damaging the installations and at least one of the containment buildings. To avoid explosion, the direct venting of hydrogen to the open atmosphere would have been a preferred design option. Now, to prevent the risk of explosion in many [pressurized water reactor](https://en.wikipedia.org/wiki/Pressurized_water_reactor) (PWR) containment buildings, a [catalyst](https://en.wikipedia.org/wiki/Catalyst)-based [recombiner](https://en.wikipedia.org/wiki/Passive_autocatalytic_recombiner) is installed that converts hydrogen and oxygen into water at room temperature before the hazard arises.[[35]](https://en.wikipedia.org/wiki/Zirconium#cite_note-recombiner-35)

**Space and aeronautic industries**

Materials fabricated from zirconium metal and ZrO2 are used in space vehicles where resistance to heat is needed.[[20]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Stwertka-20)

High temperature parts such as combustors, blades, and vanes in [jet engines](https://en.wikipedia.org/wiki/Jet_engine) and stationary [gas turbines](https://en.wikipedia.org/wiki/Gas_turbine) are increasingly being protected by thin [ceramic](https://en.wikipedia.org/wiki/Ceramic) layers, usually composed of a mixture of zirconia and [yttria](https://en.wikipedia.org/wiki/Yttrium_oxide).[[36]](https://en.wikipedia.org/wiki/Zirconium#cite_note-36)

**Positron emission tomography cameras**

The isotope 89Zr has been applied to the tracking and quantification of molecular antibodies with [positron emission tomography](https://en.wikipedia.org/wiki/Positron_emission_tomography) (PET) cameras (a method called "immuno-PET"). Immuno-PET has reached a maturity of technical development and is now entering the phase of wide-scale clinical applications.[[37]](https://en.wikipedia.org/wiki/Zirconium#cite_note-37)[[38]](https://en.wikipedia.org/wiki/Zirconium#cite_note-38)[[39]](https://en.wikipedia.org/wiki/Zirconium#cite_note-39) Until recently, radiolabeling with 89Zr was a complicated procedure requiring multiple steps. In 2001–2003 an improved multistep procedure was developed using a succinylated derivative of [desferrioxamine B](https://en.wikipedia.org/wiki/Deferoxamine) (N-sucDf) as a bifunctional [chelate](https://en.wikipedia.org/wiki/Chelate),[[40]](https://en.wikipedia.org/wiki/Zirconium#cite_note-40) and a better way of binding 89Zr to mAbs was reported in 2009. The new method is fast, consists of only two steps, and uses two widely available ingredients: 89Zr and the appropriate chelate.[[41]](https://en.wikipedia.org/wiki/Zirconium#cite_note-41)

**Biomedical applications**

Zirconium-bearing compounds are used in many biomedical applications, including dental implants and [crowns](https://en.wikipedia.org/wiki/Crown_(dentistry)), knee and hip replacements, middle-ear [ossicular](https://en.wikipedia.org/wiki/Ossicular) chain reconstruction, and other restorative and [prosthetic](https://en.wikipedia.org/wiki/Prosthesis) devices.[[42]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Lee-42)

Zirconium binds [urea](https://en.wikipedia.org/wiki/Urea), a property that has been utilized extensively to the benefit of patients with [chronic kidney disease](https://en.wikipedia.org/wiki/Chronic_kidney_disease).[[42]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Lee-42) For example, zirconium is a primary component of the [sorbent](https://en.wikipedia.org/wiki/Sorbent) column dependent dialysate regeneration and recirculation system known as the REDY system, which was first introduced in 1973. More than 2,000,000 [dialysis](https://en.wikipedia.org/wiki/Dialysis) treatments have been performed using the sorbent column in the REDY system.[[43]](https://en.wikipedia.org/wiki/Zirconium#cite_note-43) Although the REDY system was superseded in the 1990s by less expensive alternatives, new sorbent-based dialysis systems are being evaluated and approved by the U.S. [Food and Drug Administration](https://en.wikipedia.org/wiki/Food_and_Drug_Administration) (FDA). Renal Solutions developed the DIALISORB technology, a portable, low water dialysis system. Also, developmental versions of a Wearable Artificial Kidney have incorporated sorbent-based technologies.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

[Sodium zirconium cyclosilicate](https://en.wikipedia.org/wiki/Sodium_zirconium_cyclosilicate) is under investigation for oral therapy in the treatment of [hyperkalemia](https://en.wikipedia.org/wiki/Hyperkalemia). It is a highly selective oral sorbent designed specifically to trap [potassium](https://en.wikipedia.org/wiki/Potassium) ions in preference to other [ions](https://en.wikipedia.org/wiki/Ions) throughout the gastrointestinal tract.[[44]](https://en.wikipedia.org/wiki/Zirconium#cite_note-44)

A mixture of monomeric and polymeric Zr4+ and Al3+ complexes with [hydroxide](https://en.wikipedia.org/wiki/Hydroxide), [chloride](https://en.wikipedia.org/wiki/Chloride) and [glycine](https://en.wikipedia.org/wiki/Glycine), called [Aluminium zirconium tetrachlorohydrex gly](https://en.wikipedia.org/wiki/Aluminium_zirconium_tetrachlorohydrex_gly) or AZG, is used in a preparation as an antiperspirant in many deodorant products. It is selected for its ability to obstruct pores in the skin and prevent sweat from leaving the body.

**Defunct applications**

Zirconium carbonate (3ZrO2·CO2·H2O) was used in lotions to treat [poison ivy](https://en.wikipedia.org/wiki/Poison_ivy) but was discontinued because it occasionally caused skin reactions.[[7]](https://en.wikipedia.org/wiki/Zirconium#cite_note-nbb-7)

**Safety**

|  |  |
| --- | --- |
| Zirconium | |
| **Hazards** | |
| [GHS signal word](https://en.wikipedia.org/wiki/Globally_Harmonized_System_of_Classification_and_Labelling_of_Chemicals) | Not listed as hazardous[[45]](https://en.wikipedia.org/wiki/Zirconium#cite_note-45) |
| [NFPA 704](https://en.wikipedia.org/wiki/NFPA_704) | NFPA 704 four-colored diamond  [1](https://en.wikipedia.org/wiki/NFPA_704#Red)  [0](https://en.wikipedia.org/wiki/NFPA_704#Blue)  [0](https://en.wikipedia.org/wiki/NFPA_704#Yellow) |

Although zirconium has no known biological role, the human body contains, on average, 250 milligrams of zirconium, and daily intake is approximately 4.15 milligrams (3.5 milligrams from food and 0.65 milligrams from water), depending on dietary habits.[[46]](https://en.wikipedia.org/wiki/Zirconium#cite_note-46) Zirconium is widely distributed in nature and is found in all biological systems, for example: 2.86 μg/g in whole wheat, 3.09 μg/g in brown rice, 0.55 μg/g in [spinach](https://en.wikipedia.org/wiki/Spinach), 1.23 μg/g in eggs, and 0.86 μg/g in ground beef.[[47]](https://en.wikipedia.org/wiki/Zirconium#cite_note-47) Further, zirconium is commonly used in commercial products (e.g. [deodorant](https://en.wikipedia.org/wiki/Deodorant) sticks, aerosol [antiperspirants](https://en.wikipedia.org/wiki/Antiperspirants)) and also in water purification (e.g. control of [phosphorus](https://en.wikipedia.org/wiki/Phosphorus) pollution, bacteria- and pyrogen-contaminated water).[[42]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Lee-42)

Short-term exposure to zirconium powder can cause irritation, but only contact with the eyes requires medical attention.[[48]](https://en.wikipedia.org/wiki/Zirconium#cite_note-48) Persistent exposure to [zirconium tetrachloride](https://en.wikipedia.org/wiki/Zirconium_tetrachloride) results in increased mortality in rats and guinea pigs and a decrease of blood [hemoglobin](https://en.wikipedia.org/wiki/Hemoglobin) and [red blood cell](https://en.wikipedia.org/wiki/Red_blood_cell)s in dogs. However, in a study of 20 rats given a standard diet containing ~4% zirconium oxide, there were no adverse effects on growth rate, blood and urine parameters, or mortality.[[49]](https://en.wikipedia.org/wiki/Zirconium#cite_note-49) The U.S. [Occupational Safety and Health Administration](https://en.wikipedia.org/wiki/Occupational_Safety_and_Health_Administration) (OSHA) legal limit ([permissible exposure limit](https://en.wikipedia.org/wiki/Permissible_exposure_limit)) for zirconium exposure is 5 mg/m3 over an 8-hour workday. The [National Institute for Occupational Safety and Health](https://en.wikipedia.org/wiki/National_Institute_for_Occupational_Safety_and_Health) (NIOSH) [recommended exposure limit](https://en.wikipedia.org/wiki/Recommended_exposure_limit) (REL) is 5 mg/m3 over an 8-hour workday and a short term limit of 10 mg/m3. At levels of 25 mg/m3, zirconium is [immediately dangerous to life and health](https://en.wikipedia.org/wiki/IDLH).[[50]](https://en.wikipedia.org/wiki/Zirconium#cite_note-50) However, zirconium is not considered an industrial health hazard.[[42]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Lee-42) Furthermore, reports of zirconium-related adverse reactions are rare and, in general, rigorous cause-and-effect relationships have not been established.[[42]](https://en.wikipedia.org/wiki/Zirconium#cite_note-Lee-42) No evidence has been validated that zirconium is carcinogenic or genotoxic.[[51]](https://en.wikipedia.org/wiki/Zirconium#cite_note-51)

Among the numerous radioactive isotopes of zirconium, 93Zr is among the most common. It is released as a product of 235U, mainly in nuclear plants and during nuclear weapons tests in the 1950s and 1960s. It has a very long half-life (1.53 million years), its decay emits only low energy radiations, and it is not considered as highly hazardous.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

**See also**

* ***https://upload.wikimedia.org/wikipedia/commons/thumb/e/ed/Papapishu-Lab-icon-6.svg/28px-Papapishu-Lab-icon-6.svg.png***[***Chemistry portal***](https://en.wikipedia.org/wiki/Portal:Chemistry)
* [Zirconium alloys](https://en.wikipedia.org/wiki/Zirconium_alloy)
* [Zirconia light](https://en.wikipedia.org/wiki/Zirconia_light)

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* [Contributions](https://en.wikipedia.org/wiki/Special:MyContributions)
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* [Log in](https://en.wikipedia.org/w/index.php?title=Special:UserLogin&returnto=Zirconium)
* [Article](https://en.wikipedia.org/wiki/Zirconium)
* [Talk](https://en.wikipedia.org/wiki/Talk:Zirconium)
* [Read](https://en.wikipedia.org/wiki/Zirconium)
* [Edit](https://en.wikipedia.org/w/index.php?title=Zirconium&action=edit)
* [View history](https://en.wikipedia.org/w/index.php?title=Zirconium&action=history)

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Top of Form

Bottom of Form

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* [Current events](https://en.wikipedia.org/wiki/Portal:Current_events)
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* [Italiano](https://it.wikipedia.org/wiki/Zirconio)
* [Русский](https://ru.wikipedia.org/wiki/%D0%A6%D0%B8%D1%80%D0%BA%D0%BE%D0%BD%D0%B8%D0%B9)
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