

# Zirconium (Zr) - Student Datasheet

Element 40 · Transition metal · source-reviewed learning reference

Zirconium is element 40, a corrosion-resistant Group 4 metal whose low neutron-capture cross section, HCP-to-BCC phase transition and stable oxide chemistry connect the periodic table to nuclear cladding, ceramics and high-temperature materials.

## Quick reference

|                                |                                      |
|--------------------------------|--------------------------------------|
| <b>Atomic number</b>           | 40                                   |
| <b>Relative atomic mass</b>    | 91.224                               |
| <b>Electron configuration</b>  | [Kr] 4d <sup>2</sup> 5s <sup>2</sup> |
| <b>Period / group / block</b>  | 5 / 4 / d                            |
| <b>State context</b>           | Gray-white corrosion-resistant metal |
| <b>Density</b>                 | 6.52 g/cm <sup>3</sup>               |
| <b>Melting / transition</b>    | 2127 K                               |
| <b>Boiling / gas reference</b> | 4679 K                               |
| <b>Oxidation states</b>        | +4                                   |
| <b>Electronegativity</b>       | 1.33                                 |

## Structure & orbitals

$\alpha$ -zirconium is HCP near room temperature and transforms to BCC  $\beta$ -zirconium at high temperature. The structure viewer shows  $\alpha$ -Zr; the phase track marks the solid-solid transition.

The 4d<sub>z<sup>2</sup></sub>, 4d<sub>xy</sub>, 5s visuals are isolated-atom probability teaching models. They do not depict electron bands, bonding orbitals or the crystal electronic structure of Zirconium materials.

## Phase behavior

At approximately standard pressure,  $\alpha$ -Zr is HCP up to about 1136 K,  $\beta$ -Zr is BCC from there to the 2127 K melting point, liquid zirconium extends to about 4679 K, then gas.

## Five things to remember

- Atomic number 40 means 40 protons.
- Neutral Zirconium has [Kr] 4d<sup>2</sup> 5s<sup>2</sup>.
- Its representative teaching isotope is <sup>90</sup>Zr.
- Zirconium metal, zircon (a silicate mineral) and zirconia (ZrO<sub>2</sub>) are not interchangeable names.
- The ordinary material reference is hcp  $\alpha$ -zr near room temperature; bcc  $\beta$ -zr at high temperature.

# Zirconium: Real World & Signature Science

Element-specific science, uses and history

## Big idea

Zirconium metal, zircon (a silicate mineral) and zirconia ( $\text{ZrO}_2$ ) are not interchangeable names. Their structures and applications differ even though each contains zirconium atoms.

## Why this element is scientifically distinctive

Explore Zr across the teaching nucleus, isolated-atom orbitals, evidence-aware material structure and temperature/evidence views, then connect those models to uses, isotopes, search-led questions and source-backed context.

|                             |                                                                                                      |
|-----------------------------|------------------------------------------------------------------------------------------------------|
| <b>Nuclear cladding</b>     | Zirconium alloys combine corrosion resistance with low neutron absorption for reactor fuel cladding. |
| <b>Zirconia</b>             | $\text{ZrO}_2$ is a distinct ceramic with thermal, dental and structural applications.               |
| <b>Zircon</b>               | $\text{ZrSiO}_4$ is a mineral and gemstone; it is not zirconium metal.                               |
| <b>Corrosion resistance</b> | A stable oxide film helps protect zirconium metal in many environments.                              |
| <b>Phase transformation</b> | The $\alpha$ -HCP to $\beta$ -BCC transition is important in high-temperature metallurgy.            |

## From source material to Zirconium applications: high-level material path

1. Zircon minerals are beneficiated as mineral feedstock; zirconium and hafnium are chemically similar and may require separation for nuclear-grade applications.
2. Refining produces zirconium compounds or high-purity metal feedstocks.
3. Alloying/forming creates zirconium tubes, sheets or components; oxidation produces zirconia ceramics in different pathways.
4. Nuclear-grade quality control focuses on composition and neutron-absorption requirements; no process recipe is provided.

## History checkpoints

|                   |                                                                              |
|-------------------|------------------------------------------------------------------------------|
| <b>1789</b>       | Martin Heinrich Klaproth recognized zirconium in zircon mineral material.    |
| <b>1824</b>       | Jöns Jacob Berzelius prepared an impure metallic form.                       |
| <b>1920s</b>      | The van Arkel-de Boer process enabled much purer zirconium metal.            |
| <b>Modern era</b> | Zirconium alloys became important in nuclear and chemical-process materials. |

# Zirconium: Isotopes, Questions & Evidence

Evidence status and learner self-check

## Isotope context

|                                                      |                                 |                                           |
|------------------------------------------------------|---------------------------------|-------------------------------------------|
| <sup>90</sup> Zr                                     | Stable natural isotope          | Most abundant natural zirconium isotope.  |
| <sup>91</sup> Zr, <sup>92</sup> Zr, <sup>94</sup> Zr | Stable natural isotopes         | Contribute to natural zirconium.          |
| <sup>96</sup> Zr                                     | Very long-lived natural isotope | Radioactive on extremely long timescales. |

## Common questions

### What is zirconium?

Zirconium is chemical element 40, a Group 4 transition metal.

### Is zirconium a metal?

Yes. It is a gray-white, corrosion-resistant metal.

### What is zirconium used for?

Major uses include zirconium alloys in nuclear systems and zirconium compounds such as zirconia in ceramics.

### Is zircon the same as zirconium?

No. Zircon is the mineral zirconium silicate, ZrSiO<sub>4</sub>; zirconium is the element.

## Quick self-check

Q: What is Zirconium's atomic number? | Answer: 40. Atomic number equals proton count.

Q: Which classification best fits Zirconium? | Answer: Transition metal. Periodic position and chemistry define the classification.

Q: What is the representative teaching isotope? | Answer: <sup>90</sup>Zr. An isotope mass number is not the same thing as relative atomic mass.

## Evidence & safety

Atomic identity, reference values and ordinary structures are source-reviewed. Material viewers are teaching representations, not crystallographic refinements. Search demand never overrides measured/evaluated evidence or compound-vs-element distinctions.

Zirconium metal, fine powders and zirconium compounds can have very different hazards. This page does not provide reactive-metal processing instructions.

## Core sources

Royal Society of Chemistry - Zirconium

<https://periodic-table.rsc.org/element/40/zirconium>

NIST - Atomic Weights and Isotopic Compositions

[https://physics.nist.gov/cgi-bin/Compositions/stand\\_alone.pl](https://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl)

IAEA - Zirconium alloy materials context

<https://www.iaea.org/>