# Zinc

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**Zinc** is a chemical element with the symbol **Zn** and atomic number 30. It is the first element in group 12 of the periodic table. In some respects zinc is chemically similar to magnesium: both elements exhibit only one normal oxidation state (+2), and the $Zn^{2+}$ and $Mg^{2+}$ ions are of similar size. Zinc is the 24th most abundant element in Earth's crust and has five stable isotopes. The most common zinc ore is sphalerite (zinc blende), a zinc sulfide mineral. The largest workable lodes are in Australia, Asia, and the United States. Zinc is refined by froth flotation of the ore, roasting, and final extraction using electricity (electrowinning).

Brass, an alloy of copper and zinc in various proportions, was used as early as the third millennium BC in the Aegean, Iraq, the United Arab Emirates, Kalmykia, Turkmenistan and Georgia, and the second millennium BC in West India, Uzbekistan, Iran, Syria, Iraq, and Israel[2] (Judea[3]).[4] Zinc metal was not produced on a large scale until the 12th century in India and was unknown to Europe until the end of the 16th century. The mines of Rajasthan have given definite evidence of zinc production going back to the 6th century BC.[5] To date, the oldest evidence of pure zinc comes from Zawar, in Rajasthan, as early as the 9th century AD when a distillation process was employed to make pure zinc.[6] Alchemists burned zinc in air to form what they called "philosopher's wool" or "white snow".

The element was probably named by the alchemist Paracelsus after the German word *Zinke* (prong, tooth). German chemist Andreas Sigismund Marggraf is credited with discovering pure metallic zinc in 1746. Work by Luigi Galvani and Alessandro Volta uncovered the electrochemical properties of zinc by 1800. Corrosion-resistant zinc plating of iron (hot-dip galvanizing) is the major application for zinc. Other applications are in electrical batteries, small non-structural castings, and alloys such as brass. A variety of zinc compounds are commonly used, such as zinc carbonate and zinc gluconate (as dietary supplements), zinc chloride (in deodorants), zinc pyrithione (anti-dandruff shampoos), zinc sulfide (in luminescent paints), and zinc methyl or zinc diethyl in the organic laboratory.

**Zinc, $_{30}$Zn**

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|---|---|
| **General properties** | |
| **Name, symbol** | zinc, Zn |
| **Appearance** | silver-gray |
| **Zinc in the periodic table** | |
| **Atomic number** (*Z*) | 30 |
| **Group, block** | group 12, d-block |
| **Period** | period 4 |
| **Element category** | □ transition metal, alternatively considered a post-transition metal |
| **Standard atomic weight** (±) ($A_r$) | 65.38(2)[1] |
| **Electron configuration** | [Ar] $3d^{10}$ $4s^2$ |
| per shell | 2, 8, 18, 2 |
| **Physical properties** | |
| **Phase** | solid |
| **Melting point** | 692.68 K (419.53 °C, |

Zinc is an essential mineral perceived by the public today as being of "exceptional biologic and public health importance", especially regarding prenatal and postnatal development.[7] Zinc deficiency affects about two billion people in the developing world and is associated with many diseases.[8] In children, deficiency causes growth retardation, delayed sexual maturation, infection susceptibility, and diarrhea.[7] Enzymes with a zinc atom in the reactive center are widespread in biochemistry, such as alcohol dehydrogenase in humans.[9] Consumption of excess zinc can cause ataxia, lethargy and copper deficiency.

# Characteristics

## Physical properties

Zinc is a bluish-white, lustrous, diamagnetic metal,[10] though most common commercial grades of the metal have a dull finish.[11] It is somewhat less dense than iron and has a hexagonal crystal structure, with a distorted form of hexagonal close packing, in which each atom has six nearest neighbors (at 265.9 pm) in its own plane and six others at a greater distance of 290.6 pm.[12] The metal is hard and brittle at most temperatures but becomes malleable between 100 and 150 °C.[10][11] Above 210 °C, the metal becomes brittle again and can be pulverized by beating.[13] Zinc is a fair conductor of electricity.[10] For a metal, zinc has relatively low melting (419.5 °C) and boiling points (907 °C).[14] The melting point is the lowest of all the transition metals aside from mercury and cadmium.[14]

Many alloys contain zinc, including brass. Other metals long known to form binary alloys with zinc are aluminium, antimony, bismuth, gold, iron, lead, mercury, silver, tin, magnesium, cobalt, nickel, tellurium and sodium.[15] Although neither zinc nor zirconium are ferromagnetic, their alloy $ZrZn_2$ exhibits ferromagnetism below 35 K.[10]

A bar of zinc generates a characteristic sound when bent, similar to tin cry.

## Occurrence

| | |
|---|---|
| | 787.15 °F) |
| **Boiling point** | 1180 K (907 °C, 1665 °F) |
| **Density** near r.t. | 7.14 g/cm$^3$ |
| when liquid, at m.p. | 6.57 g/cm$^3$ |
| **Heat of fusion** | 7.32 kJ/mol |
| **Heat of vaporization** | 115 kJ/mol |
| **Molar heat capacity** | 25.470 J/(mol·K) |

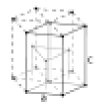
**Vapor pressure**

| **P** (Pa) | **1** | **10** | **100** | **1 k** | **10 k** | **100 k** |
|---|---|---|---|---|---|---|
| **at T** (K) | 610 | 670 | 750 | 852 | 990 | 1179 |

**Atomic properties**

| | |
|---|---|
| **Oxidation states** | -2, 0, +1, **+2** (an amphoteric oxide) |
| **Electronegativity** | Pauling scale: 1.65 |
| **Ionization energies** | 1st: 906.4 kJ/mol<br>2nd: 1733.3 kJ/mol<br>3rd: 3833 kJ/mol<br>(more) |
| **Atomic radius** | empirical: 134 pm |
| **Covalent radius** | 122±4 pm |
| **Van der Waals radius** | 139 pm |

**Miscellanea**

| | |
|---|---|
| **Crystal structure** | hexagonal close-packed (hcp)  |
| **Speed of sound** thin rod | 3850 m/s (at r.t.) (rolled) |

Zinc makes up about 75 ppm (0.0075%) of Earth's crust, making it the 24th most abundant element. Soil contains zinc in 5–770 ppm with an average 64 ppm. Seawater has only 30 ppb and the atmosphere, 0.1–4 µg/m$^3$.[16]

Sphalerite (ZnS)

The element is normally found in association with other base metals such as copper and lead in ores.[17] Zinc is a chalcophile, meaning the element has a low affinity for oxides and prefers to bond with sulfides. Chalcophiles formed as the crust solidified under the reducing conditions of the early Earth's atmosphere.[18] Sphalerite, which is a form of zinc sulfide, is the most heavily mined zinc-containing ore because its concentrate contains 60–62% zinc.[17]

Other source minerals for zinc include smithsonite (zinc carbonate), hemimorphite (zinc silicate), wurtzite (another zinc sulfide), and sometimes hydrozincite (basic zinc carbonate).[19] With the exception of wurtzite, all these other minerals were formed by weathering of the primordial zinc sulfides.[18]

Identified world zinc resources total about 1.9–2.8 billion tonnes.[20][21] Large deposits are in Australia, Canada and the United States, with the largest reserves in Iran.[18][22][23] The most recent estimate of reserve base for zinc (meets specified minimum physical criteria related to current mining and production practices) was made in 2009 and calculated to be roughly 480 Mt.[24] Zinc reserves, on the other hand, are geologically identified ore bodies whose suitability for recovery is economically based (location, grade, quality, and quantity) at the time of determination. Since exploration and mine development is an ongoing process, the amount of zinc reserves is not a fixed number and sustainability of zinc ore supplies cannot be judged by simply extrapolating the combined mine life of today's zinc mines. This concept is well supported by data from the United States Geological Survey (USGS), which illustrates that although refined zinc production increased 80% between 1990 and 2010, the reserve lifetime for zinc has remained unchanged. About 346 million tonnes have been extracted throughout history to 2002, and scholars have estimated that about 109–305 million tonnes are in use.[25][26][27]

| | |
|---|---|
| **Thermal expansion** | 30.2 µm/(m·K) (at 25 °C) |
| **Thermal conductivity** | 116 W/(m·K) |
| **Electrical resistivity** | 59.0 nΩ·m (at 20 °C) |
| **Magnetic ordering** | diamagnetic |
| **Young's modulus** | 108 GPa |
| **Shear modulus** | 43 GPa |
| **Bulk modulus** | 70 GPa |
| **Poisson ratio** | 0.25 |
| **Mohs hardness** | 2.5 |
| **Brinell hardness** | 327–412 MPa |
| **CAS Number** | 7440-66-6 |
| **History** | |
| **Discovery** | Indian metallurgists (before 1000 BCE) |
| **First isolation** | Andreas Sigismund Marggraf (1746) |
| **Recognized as a unique metal by** | Rasaratna Samuccaya (800) |
| **Most stable isotopes of zinc** | |

## Isotopes

Five isotopes of zinc occur in nature. $^{64}Zn$ is the most abundant isotope (48.63% natural abundance).[28] That isotope has such a long half-life, at $4.3 \times 10^{18}$ a,[29] that its radioactivity can be ignored.[30] Similarly, $^{70}Zn$ (0.6%), with a half-life of $1.3 \times 10^{16}$ a is not usually considered to be radioactive. The other isotopes found in nature are $^{66}Zn$ (28%), $^{67}Zn$ (4%) and $^{68}Zn$ (19%).

Several dozen radioisotopes have been characterized. $^{65}Zn$, which has a half-life of 243.66 days, is the least active radioisotope, followed by $^{72}Zn$ with a half-life of 46.5 hours.[28] Zinc has 10 nuclear isomers. $^{69m}Zn$ has the longest half-life, 13.76 h.[28] The superscript *m* indicates a metastable isotope. The nucleus of a metastable isotope is in an excited state and will return to the ground state by emitting a photon in the form of a gamma ray. $^{61}Zn$ has three excited states and $^{73}Zn$ has two.[31] The isotopes $^{65}Zn$, $^{71}Zn$, $^{77}Zn$ and $^{78}Zn$ each have only one excited state.[28]

| iso | NA | half-life | DM | DE (MeV) | DP |
|---|---|---|---|---|---|
| $^{64}Zn$ | 49.2% | is stable with 34 neutrons | | | |
| $^{65}Zn$ | syn | 243.8 d | ε | 1.3519 | $^{65}Cu$ |
| | | | γ | 1.1155 | – |
| $^{66}Zn$ | 27.7% | is stable with 36 neutrons | | | |
| $^{67}Zn$ | 4.0% | is stable with 37 neutrons | | | |
| $^{68}Zn$ | 18.5% | is stable with 38 neutrons | | | |
| $^{69}Zn$ | syn | 56 min | β− | 0.906 | $^{69}Ga$ |
| $^{69m}Zn$ | syn | 13.76 h | β− | 0.906 | $^{69}Ga$ |
| $^{70}Zn$ | 0.6% | is stable with 40 neutrons | | | |
| $^{71}Zn$ | syn | 2.4 min | β− | 2.82 | $^{71}Ga$ |
| $^{71m}Zn$ | syn | 3.97 d | β− | 2.82 | $^{71}Ga$ |
| $^{72}Zn$ | syn | 46.5 h | β− | 0.458 | $^{72}Ga$ |

The most common decay mode of a radioisotope of zinc with a mass number lower than 66 is electron capture. The decay product resulting from electron capture is an isotope of copper.[28]

$$^{n}_{30}Zn + e^{-} \rightarrow ^{n}_{29}Cu$$

The most common decay mode of a radioisotope of zinc with mass number higher than 66 is beta decay ($\beta^-$), which produces an isotope of gallium.[28]

$$^{n}_{30}Zn \rightarrow ^{n}_{31}Ga + e^{-} + \bar{\nu}_e$$

# External links

- Wikipedia: Zinc (https://en.wikipedia.org/wiki/Zinc)