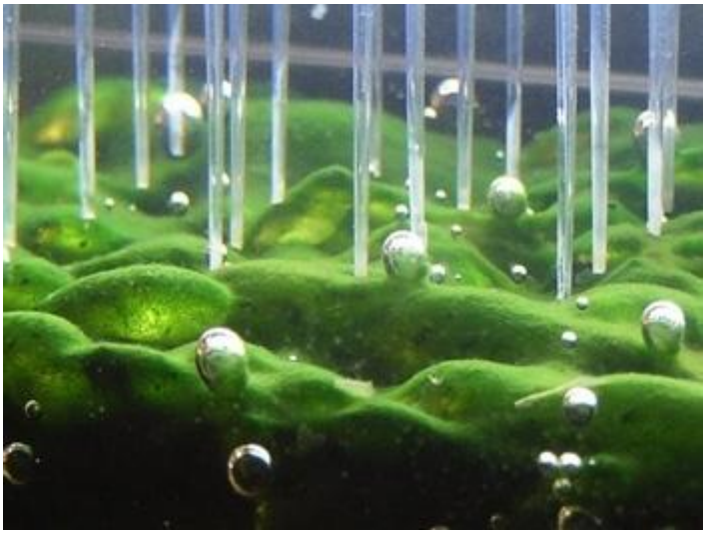
Zinc



Zinc absorbing into biofilm; vertical rods are microelectrodes. Jeffrey Morris/USGS

Previous Element:Copper **Next Element:Gallium**	30 **Zn** 65.39
Physical Properties	
Color	silvery
Phase at Room Temp.	solid
Density (g/cm^3)	7.14
Hardness (Mohs)	2.5
Melting Point (K)	692.78
Boiling Point (K)	1180
Heat of Fusion (kJ/mol)	6.7
Heat of Vaporization (kJ/mol)	115
Heat of Atomization (kJ/mol)	131
Thermal Conductivity (J/m sec K)	116
Electrical Conductivity (1/mohm cm)	169.033
Source	Sphalerite (sulfide)
Atomic Properties	
Electron Configuration	[Ar]3d^{10}4s^2
Number of Isotopes	5
Electron Affinity (kJ/mol)	---

First Ionization Energy (kJ/mol)	906.4
Second Ionization Energy (kJ/mol)	1733.2
Third Ionization Energy (kJ/mol)	3832.6
Electronegativity	1.65
Polarizability (Å^{3})	6.4
Atomic Weight	65.39
Atomic Volume (cm^{3}/mol)	9.2
Ionic Radius^{2-} (pm)	---
Ionic Radius^{1-} (pm)	---
Atomic Radius (pm)	134
Ionic Radius^{1+} (pm)	---
Ionic Radius^{2+} (pm)	88
Ionic Radius^{3+} (pm)	---
Common Oxidation Numbers	+2
Other Oxid. Numbers	
Abundance	
In Earth's Crust (mg/kg)	7.0×10^{1}
In Earth's Ocean (mg/L)	4.9×10^{-3}
In Human Body (%)	0.003%
Regulatory / Health	
CAS Number	7440-66-6
OSHA Permissible Exposure Limit (PEL)	No limits
OSHA PEL Vacated 1989	No limits
NIOSH Recommended Exposure Limit (REL)	No limits
Source: Mineral Information Institute	

Zinc is a metallic chemical element, with atomic symbol **Zn**and atomic number 30. It is the first element in Group 12 of the Periodic table. Zinc is chemically similar to the element magnesium, since the ionic radius is of comparable size, and the only common oxidation state is plus two. Zinc is the 24th most abundant element within the Earth's crust and has five stable isotopes. The most commonly mined zinc ore is sphalerite, a form of zinc sulfide. The largest occurrences of this zinc ore deposits are found in Australia, Canada, and the USA. Zinc production includes froth flotation of the ore, roasting, and final extraction using electricity.

Physical properties

In pure metallic form zinc is a bluish-white, lustrous, diamagnetic solid, even though common commercial grades of the metal exhibit a dull finish. The element manifests slightly less density than metallic iron. Relative to other metals zinc offers a low melting temperature; in fact zinc's melting point is below that of any transition metal with the exceptions of mercury and cadmium. Zinc also possesses a low boiling point relative to other heavy metals. This metal is brittle and hard at typical ambient termperatures, and is malleable between 100 and 150°C; however, once the temperature rises above 210°C, zinc again becomes brittle and is readily pulverized. Zinc exhibits moderate electrical conductivity. Metallic zinc displays a hexagonal crystal structure.

Chemical properties

Zinc burns in air with a bright bluish-green flame, yielding fumes of zinc oxide. Reactions of zinc are evident with acids, bases and many non-metals. Strong acids, including hydrochloric and sulfuric acid, can remove the thin coating layer of zinc carbonate formed when pure metallic zinc is exposed to carbon dioxide in the atmosphere.

Zinc's outer electron shells feature ten electrons in the 3d shell and two electrons in the 4s shell, making it a member of group 12 of the periodic table. Zinc manifests itself as a somewhat reactive metal; moreover, it is a potent reducing agent. Most of zinc's chemistry is dominated by the +2 oxidation state, although some instances of the +1 state are found such as the compound Zn_2Cl_2, that occurs at temperatures above 285^{o}C.

Common zinc compounds include zinc nitrate, zinc chlorate, zinc nitrate, zinc phosphate and zinc sulfate, all representative of the oxidation state +2. Less common compounds are formed with the nitrogen group, including: zinc nitride, $Zn_3N_{2;}$ zinc phosphide, Zn_3P_2; zinc arsenide, $Zn_3As_{2;}$ and zinc antimonide, Zn_3Sb_2. Zinc organic compounds are characterized by zinc–carbon covalent bonds.

Natural occurrence

Zinc comprises approximately 75 parts per million (ppm) of the Earth's crust, making it the 24th most abundant element. Typical soil concentrations range from five to 770 ppm of zinc, with an average of about 60 ppm. Oceans contain 30 ppb zinc, and air has 0.1–4.0 µg of zinc per cubic meter.

Zinc is normally found in ores affiliated with other heavy metals like copper and lead. Zinc is a Goldschmidt chalcophile, indicating a low affinity for oxide formation relative to sulfide bond formation. Chalcophiles formed when the Earth crust solidified under the reducing conditions of the early Earth's atmosphere. Sphalerite, a form of zinc sulfide, is the most heavily mined zinc ore, since its concentrate exhibits 60 to 62 percent zinc.

Other minerals yielding zinc include zinc carbonate, hemimorphite (zinc silicate), wurtzite (also a zinc sulfide), and hydrozincite (a basic form of zinc carbonate). With the exception of wurtzite, the other zinc ores were formed as a result of weathering processes on the primordial zinc sulfides.

Isotopes

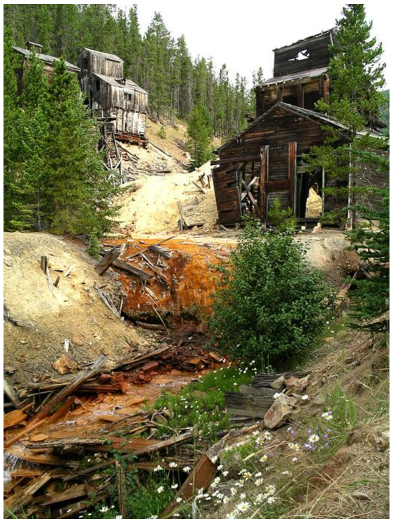
There are five naturally occurring isotopes of zinc. ^{64}Zn, the most abundant isotope (49% natural abundance), has a half-life of 4.3 x 10^{18} years. In like manner, ^{70}Zn (abundance 0.6%), exhibiting a half life of 1.3 x 10^{16} years, is typically considered to be stable isotope. The other isotopes occurring in the Earth's crust are ^{66}Zn (28%), ^{67}Zn (4%) and ^{68}Zn (19%).

Zinc isotopic fractionation.

Over thirty man-made radioisotopes have been created. ^{65}Zn, which has a half-life of 243.66 days, is the most long-lived isotope, followed by ^{72}Zn with a half-life of 46.5 hours. Zinc has ten nuclear isomers. ^{69m}Zn has the longest half-life, 13.76 hours, with the superscript *m* denoting a metastable isotope. The nucleus of a metastable isotope exists in an excited state and reverts to the ground state by emitting a gamma ray. ^{61}Zn exhibits three excited states and ^{73}Zn manifests two. Zinc synthetic isotopes ^{65}Zn, ^{71}Zn,^{77}Zn and ^{78}Zn all possess merely a single excited state.

For zinc radioisotopes of atomic mass 65 and lower, the most common decay mode is via electron capture, with the chief decay product being a copper isotope. For zinc isotopes with mass 66 and above, the most characteristic decay mode is through beta decay, a step that results in a gallium isotope.

Environmental pathways



Abandoned mine at Galena Creek, Montana

where zinc entered the food chain.

Source: U.S.Geological Sirvey

Zinc enters the atmosphere, surface waters and soil via both natural processes and human activities. Most zinc enters the environment as the result of mining, purifying of zinc, lead and cadmium ores, steel production, coal combustion and garbage combustion. Liquid waste streams from zinc and other metal manufacturing and zinc chemical industries, domestic wastewater, and surface runoff from soil containing zinc can release zinc into waterways. Zinc in soil increases chiefly from zinc disposal from metal manufacturing industries and coal ash from electric utilities. Sludge and fertilizers contribute to increased levels of zinc into soil. In air, zinc is present mainly as fine dust particles. This dust eventually settlesout over land and water, with precipitation removing zinc from the air. Most of the zinc in lakes or rivers settles to the bottom. However, a small amount may remain either dissolved in water or as fine suspended particles. The level of dissolved zinc in water may increase as the acidity of water increases. Fish and other aquatic organisms can accumulate zinc in their bodies from the water and from the food they ingest. Most of the zinc in soil is bound to soil particles and does not dissolve in water. However, depending on the type of soil, some zinc may reach aquifers, and contamination of groundwater has occurred at some hazardous waste sites. Zinc may be taken up by animals eating soil organisms or drinking water containing zinc. Zinc is also a trace mineral nutrient and as such, small amounts of zinc are needed in all animals.

Human health

Zinc is classified as an essential trace element, necessary for metabolism in human cells as well as other fauna and flora, and also for microorganisms. Cell growth and division simply will not occur without the presence of zinc. There are approximately two to three grams of zinc present in an adult human. However, zinc is unevenly distributed within the human body, as is also the case in other higher animals, where disproportionate concentrations are found in the eyes, brain, kidney, liver, bones and male reproductive organs. Zinc occurs as a co-factor of over two hundred distinct human enzymes, which are notable in protein synthesis and hormone function. In protein structures zinc ions are frequently coordinated with the individual amino acid side chains of histidine, aspartic acid, glutamic acid and cysteine. The metal is stored within metallothioneins; furthermore, it is the sole metallic element which occurs in every enzyme class. Conversely at high dosages zinc exhibits certain toxic properties.

History

Brass baptismal font, Liege, 12th c AD.

Source: Jean-Pol GrandmontIt is difficult to ascertain the exact antiquity era regarding earliest use of zinc, since many artifiacts contain zinc at less than two percent, which level can occur merely as an impurity in other metal ores. Archaeological recovery suggests that brass objects were produced in the Aegean and as far east as Eurasian Georgia as early as the third millennium BC. More detailed evidence of brass technology have been recovered in the Anatolian region (modern day Turkey) dating to the second millennium BC; however, the first reliable historical reports of mining and using zinc ores in brass are from 8th century BC Phoenician Sardinia; there is later note by Pliny and Strabo of copper ores containing zinc on Cyprus. Diffusion of brass technology seems to have reached China via Persia by at least the third century BC. The explosion of brass technology occurs in widespread Greco Roman use of brass metallurgy in the classical period, including Dacian finds and Romano British occurrences. Due to the technical difficulty in isolating zinc in elemental form, it is unlikely the ancients knew zinc in its pure elemental form, but only through its mineral forms and the alloy brass.

In medieval times the ability to distill pure zinc may have occurred as early as the tenth century AD. After that era there was widespread European innovation of alloy sophistication and casting to create a prolific and diversified brass industry which found uses in military, jewelry, and architectural applications.

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