Indium

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Indium is a chemical element with symbol **In** and atomic number 49. It is a post-transition metal that makes up 0.21 parts per million of the Earth's crust. Very soft and malleable, Indium has a melting point higher than sodium and gallium, but lower than lithium or tin. Ferdinand Reich and Hieronymous Theodor Richter discovered it with spectroscopy in 1863, naming it for the indigo blue line in its spectrum. It was isolated the next year.

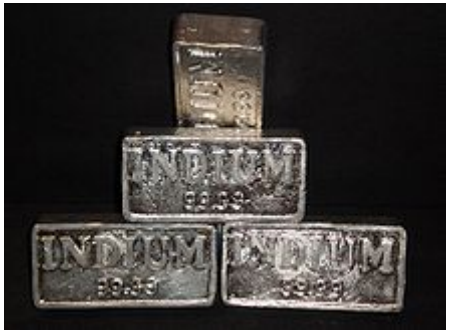
Chemically, indium is similar to gallium and thallium, and it is largely intermediate between the two in terms of its properties.[5] It is a minor component in zinc sulfide ores and is produced as a byproduct of zinc refinement. It is most notably used in the semiconductor industry, in low-melting-point metal alloys such as solders, in soft-metal high-vacuum seals, and in the production of transparent conductive coatings of indium tin oxide (ITO) on glass. Indium has no biological role, though its compounds are somewhat toxic when injected into the bloodstream. Most occupational exposure is through ingestion, from which indium compounds are not absorbed well, and inhalation, from which they are moderately absorbed.

Properties

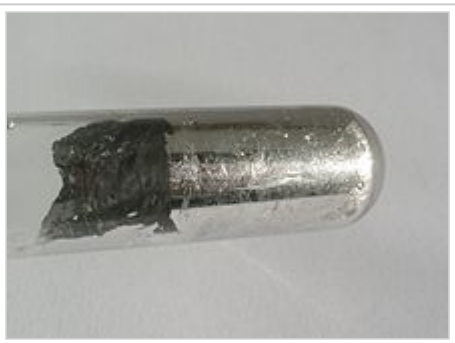
Physical

Indium is a silvery-white, highly ductile post-transition metal with a bright luster.[6] It is so soft (Mohs hardness 1.2) that like sodium, it can be cut with a knife. It also leaves a visible line on paper.[7] It is a member of group 13 on the periodic table and its properties are mostly intermediate between its vertical neighbours gallium and thallium. Like tin, a high-pitched cry is heard when indium is bent – a crackling sound due to crystal twinning.[6] Like gallium, indium is able to wet glass. Like both, indium has a low melting point, 156.60 °C (313.88 °F); higher than its lighter homologue, gallium, but lower than its heavier homologue, thallium, and lower than tin.[8] The boiling point is 2072 °C (3762 °F), higher than that of thallium, but lower than

Indium, $_{49}$In



General properties	
Name, symbol	indium, In
Appearance	silvery lustrous gray
Indium in the periodic table	
Atomic number (Z)	49
Group, block	group 13, p-block
Period	period 5
Element category	□ post-transition metal
Standard atomic weight (±) (A_r)	114.818(1)[1]
Electron configuration	[Kr] $4d^{10}$ $5s^2$ $5p^1$
per shell	2, 8, 18, 18, 3
Physical properties	
Phase	solid
Melting point	429.7485 K (156.5985 °C, 313.8773 °F)



Indium wetting the glass surface of a test tube

gallium, conversely to the general trend of melting points, but similarly to the trends down the other post-transition metal groups because of the weakness of the metallic bonding with few electrons delocalized.[9]

The density of indium, 7.31 g/cm^3, is also greater than gallium, but lower than thallium. Below the critical temperature, 3.41 K, indium becomes a superconductor. At standard temperature and pressure, indium crystallizes in the face-centered tetragonal crystal system in the space group *I*4/*mmm* (lattice parameters: a = 325 pm, c = 495 pm):[8] this is a slightly distorted face-centered cubic structure, where each indium atom has four neighbours at 324 pm distance and eight neighbours slightly further (336 pm).[10]

Chemical

Indium has 49 electrons, with an electronic configuration of [Kr]4d^{10}5s^{2}5p^1. In compounds, indium most commonly donates the three outermost electrons to become indium(III), In^{3+}. In some cases, the pair of 5s-electrons are not donated, resulting in indium(I), In$^+$. The stabilization of the monovalent state is attributed to the inert pair effect, in which relativistic effects stabilize the 5s-orbital, observed in heavier elements. Thallium (indium's heavier homolog) shows an even stronger effect, causing oxidation to thallium(I) to be more probable than to thallium(III),[11] whereas gallium (indium's lighter homolog) commonly shows only the +3 oxidation state. Thus, although thallium(III) is a moderately strong oxidizing agent, indium(III) is not, and many indium(I) compounds are powerful reducing agents.[12] While the energy required to include the s-electrons in chemical bonding is lowest for indium among the group 13 metals, bond energies decrease down the group so that by indium, the energy released in forming two additional bonds and attaining the +3 state is not always enough to outweigh the energy needed to involve the 5s-electrons.[13] Indium(I) oxide and hydroxide are more basic and indium(III) oxide and hydroxide are more acidic.[13]

Boiling point	2345 K (2072 °C, 3762 °F)
Density near r.t.	7.31 g/cm^3
when liquid, at m.p.	7.02 g/cm^3
Triple point	429.7445 K, ~1 kPa[2]
Heat of fusion	3.281 kJ/mol
Heat of vaporization	231.8 kJ/mol
Molar heat capacity	26.74 J/(mol·K)

Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1196	1325	1485	1690	1962	2340

Atomic properties

Oxidation states	**3**, 2, 1, −1, −2, −5[3] (an amphoteric oxide)
Electronegativity	Pauling scale: 1.78
Ionization energies	1st: 558.3 kJ/mol 2nd: 1820.7 kJ/mol 3rd: 2704 kJ/mol
Atomic radius	empirical: 167 pm
Covalent radius	142±5 pm
Van der Waals radius	193 pm

Miscellanea

Crystal structure	tetragonal
Speed of sound thin rod	1215 m/s (at 20 °C)

A number of standard electrode potentials, depending on the reaction under study,[14] are reported for indium, reflecting the decreased stability of the +3 oxidation state:[10]

−0.40	$In^{2+} + e^- \leftrightarrow In^+$
−0.49	$In^{3+} + e^- \leftrightarrow In^{2+}$
−0.443	$In^{3+} + 2\ e^- \leftrightarrow In^+$
−0.3382	$In^{3+} + 3\ e^- \leftrightarrow In$
−0.14	$In^+ + e^- \leftrightarrow In$

Indium metal does not react with water, but it is oxidized by stronger oxidizing agents such as halogens to give indium(III) compounds. It does not form a boride, silicide, or carbide, and the hydride InH_3 has at best a transitory existence in ethereal solutions at low temperatures, being unstable enough to spontaneously polymerize without coordination.[12] Indium is rather basic in aqueous solution, showing only slight amphoteric characteristics, and unlike its lighter homologs aluminium and gallium, it is insoluble in aqueous alkaline solutions.[15]

Thermal expansion	32.1 µm/(m·K) (at 25 °C)
Thermal conductivity	81.8 W/(m·K)
Electrical resistivity	83.7 nΩ·m (at 20 °C)
Magnetic ordering	diamagnetic[4]
Young's modulus	11 GPa
Mohs hardness	1.2
Brinell hardness	8.8–10.0 MPa
CAS Number	7440-74-6
History	
Discovery	Ferdinand Reich and Hieronymous Theodor Richter (1863)
First isolation	Hieronymous Theodor Richter (1864)

Most stable isotopes of indium

iso	NA	half-life	DM	DE (MeV)	DP
^{113}In	4.28%	is stable with 64 neutrons			
^{115}In	95.72%	4.41×10^{14} y	β^-	0.495	^{115}Sn

Isotopes

Indium has 39 known isotopes, ranging in mass number from 97 to 135. Only two isotopes occur naturally as primordial nuclides: indium-113, the only stable isotope, and indium-115, which has a half-life of 4.41×10^{14} years, four orders of magnitude greater than the age of the universe and nearly 50,000 times greater than that of natural thorium.[16] The half-life of ^{115}In is very long because the beta decay to ^{115}Sn is spin-forbidden.[17] Indium-115 makes up 95.7% of all indium. Indium is one of three known elements (the others being tellurium and rhenium) of which the stable isotope is less abundant in nature than the long-lived primordial radioisotopes.[18]

The stablest artificial isotope is indium-111, with a half-life of approximately 2.8 days. All other isotopes have half-lives shorter than 5 hours. Indium also has 47 meta states, among which indium-114m1 (half-life about 49.51 days) is the most stable, more stable than the ground state of any indium isotope other than the primordial. All decay by isomeric transition. The indium isotopes lighter than ^{115}In predominantly decay through electron capture or positron emission to form cadmium isotopes, while the other indium isotopes from ^{115}In and greater predominantly decay through beta minus decay to form tin isotopes.[16]

Source

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