

Tin

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Tin is a chemical element with the symbol **Sn** (for Latin: *stannum*) and atomic number 50, is a post-transition metal in group 14 of the periodic table. It is obtained chiefly from the mineral cassiterite, which contains tin dioxide, SnO₂.

Tin shows a chemical similarity to both of its neighbors in group 14, germanium and lead, and has two main oxidation states, +2 and the slightly more stable +4. Tin is the 49th most abundant element and has, with 10 stable isotopes, the largest number of stable isotopes in the periodic table, thanks to its magic number of protons. It has two main allotropes: at room temperature, the stable allotrope is β-tin, a silvery-white, malleable metal, but at low temperatures it transforms into the less dense grey α-tin, which has the diamond cubic structure. Metallic tin is not easily oxidized in air.

The first alloy used on a large scale was bronze, made of tin and copper, from as early as 3000 BC. After 600 BC, pure metallic tin was produced. Pewter, which is an alloy of 85–90% tin with the remainder commonly consisting of copper, antimony, and lead, was used for flatware from the Bronze Age until the 20th century. In modern times, tin is used in many alloys, most notably tin/lead soft solders, which are typically 60% or more tin. Another large application for tin is corrosion-resistant tin plating of steel. Inorganic tin compounds are rather non-toxic. Because of its low toxicity, tin-plated metal was used for food packaging as tin cans, which are now made mostly of steel, even though the name is kept in English. However, overexposure to tin may cause problems with metabolizing essential trace elements such as copper and zinc, and some organotin compounds can be almost as toxic as cyanide.

Characteristics

Physical properties

Tin is a soft, malleable, ductile and highly crystalline silvery-white metal. When a bar of tin is bent, a crackling sound known as the "tin cry" can be heard from the twinning of the crystals.^[5] Tin melts at the low temperature of about

Tin, ⁵⁰Sn



left: white, beta, β; right: gray, alpha, α

General properties

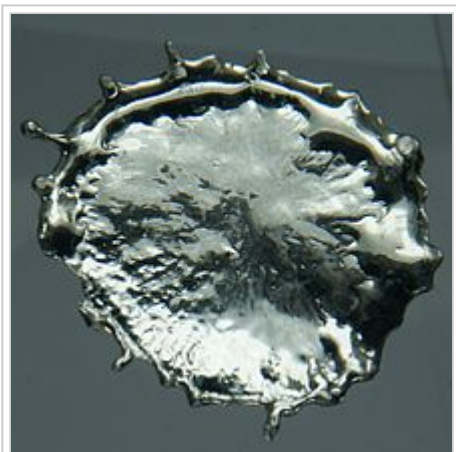
Name, symbol	tin, Sn
Allotropes	alpha, α (gray); beta, β (white)
Appearance	silvery-white (beta, β) or gray (alpha, α)

Tin in the periodic table

Atomic number (<i>Z</i>)	50
Group, block	group 14 (carbon group), p-block
Period	period 5
Element category	 post-transition metal
Standard atomic weight (<i>A</i> _r)	118.710(7) ^[1]
Electron configuration	[Kr] 4d ¹⁰ 5s ² 5p ²
per shell	2, 8, 18, 18, 4

Physical properties

Phase	solid
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Droplet of solidified molten tin

232 °C (450 °F), the lowest in group 14. The melting point is further lowered to 177.3 °C (351.1 °F) for 11 nm particles.^[6]

β -tin (the metallic form, or white tin), which is stable at and above room temperature, is malleable. In contrast, α -tin (nonmetallic form, or gray tin), which is stable below 13.2 °C (55.8 °F), is brittle. α -tin has a diamond cubic crystal structure, similar to diamond, silicon or germanium. α -tin has no metallic properties at all because its atoms form a covalent structure in which electrons cannot move freely. It is a dull-gray powdery material with no common uses other than a few specialized

semiconductor applications.^[5] These two allotropes, α -tin and β -tin, are more commonly known as *gray tin* and *white tin*, respectively. Two more allotropes, γ and σ , exist at temperatures above 161 °C (322 °F) and pressures above several GPa.^[7] In cold conditions, β -tin tends to transform spontaneously into α -tin, a phenomenon known as "tin pest".^[8] Although the α - β transformation temperature is nominally 13.2 °C (55.8 °F), impurities (e.g. Al, Zn, etc.) lower the transition temperature well below 0 °C (32 °F) and, on the addition of Sb or Bi, the transformation may not occur at all, increasing the durability of the tin.^[9]

Commercial grades of tin (99.8%) resist transformation because of the inhibiting effect of the small amounts of bismuth, antimony, lead, and silver present as impurities. Alloying elements such as copper, antimony, bismuth, cadmium, and silver increase its hardness. Tin tends rather easily to form hard, brittle intermetallic phases, which are often undesirable. It does not form wide solid solution ranges in other metals in general, and few elements have appreciable solid solubility in tin. Simple eutectic systems, however, occur with bismuth, gallium, lead, thallium and zinc.^[9]

Melting point	505.08 K (231.93 °C, 449.47 °F)
Boiling point	2875 K (2602 °C, 4716 °F)
Density near r.t.	white, β : 7.265 g/cm ³ gray, α : 5.769 g/cm ³
when liquid, at m.p.	6.99 g/cm ³
Heat of fusion	white, β : 7.03 kJ/mol
Heat of vaporization	white, β : 296.1 kJ/mol
Molar heat capacity	white, β : 27.112 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	1497	1657	1855	2107	2438	2893

Atomic properties

Oxidation states	4, 3,^[2] 2, 1,^[3] −1, −2, −3, −4 (an amphoteric oxide)
Electronegativity	Pauling scale: 1.96
Ionization energies	1st: 708.6 kJ/mol 2nd: 1411.8 kJ/mol 3rd: 2943.0 kJ/mol
Atomic radius	empirical: 140 pm
Covalent radius	139±4 pm
Van der Waals radius	217 pm

Miscellanea

Crystal structure	tetragonal white (β)
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Crystal structure	face-centered diamond-cubic
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Tin becomes a superconductor below 3.72 K^[10] and was one of the first superconductors to be studied; the Meissner effect, one of the characteristic features of superconductors, was first discovered in superconducting tin crystals.^[11]


Chemical properties

Tin resists corrosion from water, but can be attacked by acids and alkalis. Tin can be highly polished and is used as a protective coat for other metals.^[5] A protective oxide (passivation) layer prevents further oxidation, the same that forms on pewter and other tin alloys.^[12] Tin acts as a catalyst when oxygen is in solution and helps accelerate chemical attack.^[5]

Isotopes

Tin has ten stable isotopes, with atomic masses of 112, 114 through 120, 122 and 124, the greatest number of any element. Of these, the most abundant are ¹²⁰Sn (almost a third of all tin), ¹¹⁸Sn, and ¹¹⁶Sn, while the least abundant is ¹¹⁵Sn. The isotopes with even mass numbers have no nuclear spin, while those with odd have a spin of +1/2. Tin, with its three common isotopes ¹¹⁶Sn, ¹¹⁸Sn and ¹²⁰Sn, is among the easiest elements to detect and analyze by NMR spectroscopy, and its chemical shifts are referenced against SnMe₄.^{[note 1][13]}

This large number of stable isotopes is thought to be a direct result of the atomic number 50, a "magic number" in nuclear physics. Tin also occurs in 29 unstable isotopes, encompassing all the remaining atomic masses from 99 to 137. Apart from ¹²⁶Sn, with a half-life of 230,000 years, all the radioisotopes have a half-life of less than a year. The radioactive ¹⁰⁰Sn, discovered in 1994, and ¹³²Sn are one of the few nuclides with a "doubly magic" nucleus: despite being unstable, having very lopsided proton-neutron ratios, they represent endpoints beyond which stability drops off rapidly.^[14] Another 30 metastable isomers have been characterized for isotopes between 111 and 131, the most stable being ^{121m}Sn with a half-life of 43.9 years.^[15]

	gray (α)	
Speed of sound thin rod	2730 m/s (at r.t.) (rolled)	
Thermal expansion	22.0 μm/(m·K) (at 25 °C)	
Thermal conductivity	66.8 W/(m·K)	
Electrical resistivity	115 nΩ·m (at 0 °C)	
Magnetic ordering	gray: diamagnetic ^[4] white (β): paramagnetic	
Young's modulus	50 GPa	
Shear modulus	18 GPa	
Bulk modulus	58 GPa	
Poisson ratio	0.36	
Brinell hardness	50–440 MPa	
CAS Number	7440-31-5	
	History	
Discovery	around 3500 BC	
Most stable isotopes of tin		

The relative differences in the abundances of tin's stable isotopes can be explained by their different modes of formation in stellar nucleosynthesis. ¹¹⁶Sn through ¹²⁰Sn inclusive are formed in the s-process (slow neutron capture) in most stars and hence they are the most common isotopes, while ¹²²Sn and ¹²⁴Sn are only formed in the r-process (rapid neutron capture) in supernovae and are less common. (The isotopes ¹¹⁷Sn through ¹²⁰Sn also receive contributions from the r-process.) Finally, the rarest proton-rich isotopes, ¹¹²Sn, ¹¹⁴Sn, and ¹¹⁵Sn, cannot be made in significant amounts in the s- or r-processes and are considered among the p-nuclei, whose origins are not well-understood yet. Some speculated mechanisms for their formation include proton capture as well as photodisintegration, although ¹¹⁵Sn may also be partially produced in the s-process, both directly, and as the daughter of long-lived ¹¹⁵In.^[16]

External links

- Wikipedia: Tin (<https://en.wikipedia.org/wiki/Tin>)

iso	NA	half-life	DM	DE (MeV)	DP
112 Sn	0.97%	is stable with 62 neutrons			
114 Sn	0.66%	is stable with 64 neutrons			
115 Sn	0.34%	is stable with 65 neutrons			
116 Sn	14.54%	is stable with 66 neutrons			
117 Sn	7.68%	is stable with 67 neutrons			
118 Sn	24.22%	is stable with 68 neutrons			
119 Sn	8.59%	is stable with 69 neutrons			
120 Sn	32.58%	is stable with 70 neutrons			
122 Sn	4.63%	is stable with 72 neutrons			
124 Sn	5.79%	is stable with 74 neutrons			
126 Sn	trace	2.3×10 ⁵ y	β [−]	0.378	¹²⁶ Sb