Thallium

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Thallium is a chemical element with symbol **Tl** and atomic number 81. This soft gray post-transition metal is not found free in nature. When isolated, it resembles tin, but discolors when exposed to air. Chemists William Crookes and Claude-Auguste Lamy discovered thallium independently in 1861, in residues of sulfuric acid production. Both used the newly developed method of flame spectroscopy, in which thallium produces a notable green spectral line. Thallium, from Greek *θαλλός*, *thallos*, meaning "a green shoot or twig," was named by Crookes. It was isolated by both Lamy and Crookes in 1862; Lamy by electrolysis and Crookes by precipitation and melting of the resultant powder. Crookes exhibited it as a powder precipitated by Zinc at the International exhibition which opened on 1 May, that year.[5]

Thallium tends to oxidize to the +3 and +1 oxidation states as ionic salts. The +3 state resembles that of the other elements in group 13 (boron, aluminium, gallium, indium). However, the +1 state, which is far more prominent in thallium than the elements above it, recalls the chemistry of alkali metals, and thallium(I) ions are found geologically mostly in potassium-based ores, and (when ingested) are handled in many ways like potassium ions (K^+) by ion pumps in living cells.

Commercially, however, thallium is produced not from potassium ores, but as a byproduct from refining of heavy metal sulfide ores. Approximately 60–70% of thallium production is used in the electronics industry, and the remainder is used in the pharmaceutical industry and in glass manufacturing.[6] It is also used in infrared detectors. The radioisotope thallium-201 (as the soluble chloride TlCl) is used in small, nontoxic amounts as an agent in a nuclear medicine scan, during one type of nuclear cardiac stress test.

Soluble thallium salts (many of which are nearly tasteless) are highly toxic in quantity, and were historically used in rat poisons and insecticides. Use of these compounds has been restricted or banned in many countries, because of their nonselective toxicity. Notably, thallium poisoning results in hair loss. Because of its historic popularity as a murder weapon, thallium has gained notoriety as "the poisoner's poison" and "inheritance powder" (alongside arsenic).[7]

Thallium, $_{81}$Tl

General properties	
Name, symbol	thallium, Tl
Appearance	silvery white
Thallium in the periodic table	
Atomic number (Z)	81
Group, block	group 13, p-block
Period	period 6
Element category	□ post-transition metal
Standard atomic weight (A_r)	204.38[1] (204.382–204.385)[2]
Electron configuration	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^1$
per shell	2, 8, 18, 32, 18, 3
Physical properties	
Phase	solid
Melting point	577 K (304 °C, 579 °F)
Boiling point	1746 K (1473 °C, 2683 °F)

Characteristics

A thallium atom has 81 electrons, arranged in the electron configuration $[Xe]4f^{14}5d^{10}6s^{2}6p^{1}$; of these, the three outermost electrons in the sixth shell are valence electrons. However, due to the inert pair effect, the 6s electron pair is relativistically stabilised and it is more difficult to get them involved in chemical bonding than for the heavier elements. Thus, very few electrons are available for metallic bonding, similar to the neighboring elements mercury and lead, and hence thallium, like its congeners, is a soft, highly electrically conducting metal with a low melting point of 304 °C.[8]

A number of standard electrode potentials, depending on the reaction under study,[9] are reported for thallium, reflecting the greatly decreased stability of the +3 oxidation state:[8]

$+0.73 \quad Tl^{3+} + 3\ e^{-} \leftrightarrow Tl$

$-0.336\ Tl^{+} + e^{-} \quad \leftrightarrow Tl$

Indeed, thallium is the first element in group 13 where the reduction of the +3 oxidation state to the +1 oxidation state is spontaneous under standard conditions.[8] Since bond energies decrease down the group, by thallium, 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 6s-electrons.[10] Accordingly, thallium(I) oxide and hydroxide are more basic and thallium(III) oxide and hydroxide are more acidic, showing that thallium conforms to the general rule of elements being more electropositive in their lower oxidation states.[10]

Thallium is malleable and sectile enough to be cut with a knife at room temperature. It has a metallic luster that, when exposed to air, quickly tarnishes to a bluish-gray tinge, resembling lead. It may be preserved by immersion in oil. A heavy layer of oxide builds up on thallium if left in air. In the presence of water, thallium hydroxide is formed. Sulfuric and nitric acid dissolve thallium rapidly to make the sulfate and nitrate salts, while hydrochloric acid forms an insoluble thallium(I) chloride layer.[11]

Density near r.t.	11.85 g/cm^3
when liquid, at m.p.	11.22 g/cm^3
Heat of fusion	4.14 kJ/mol
Heat of vaporization	165 kJ/mol
Molar heat capacity	26.32 J/(mol·K)

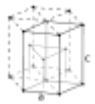
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	882	977	1097	1252	1461	1758

Atomic properties

Oxidation states	**3**, 2, **1**, −1, −2, −5[3] (a mildly basic oxide)
Electronegativity	Pauling scale: 1.62
Ionization energies	1st: 589.4 kJ/mol 2nd: 1971 kJ/mol 3rd: 2878 kJ/mol
Atomic radius	empirical: 170 pm
Covalent radius	145±7 pm
Van der Waals radius	196 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	818 m/s (at 20 °C)
Thermal expansion	29.9 µm/(m·K) (at 25 °C)
Thermal conductivity	46.1 W/(m·K)
Electrical	0.18 µΩ·m (at 20 °C)

Isotopes

Thallium has 25 isotopes which have atomic masses that range from 184 to 210. ^{203}Tl and ^{205}Tl are the only stable isotopes and make up nearly all of natural thallium. ^{204}Tl is the most stable radioisotope, with a half-life of 3.78 years.[12] It is made by the neutron activation of stable thallium in a nuclear reactor.[12][13] The most useful radioisotope, ^{201}Tl (half-life 73 hours), decays by electron capture, emitting Hg X-rays (~70–80 keV), and photons of 135 and 167 keV in 10% total abundance;[12] therefore it has good imaging characteristics without excessive patient radiation dose. It is the most popular isotope used for thallium nuclear cardiac stress tests.[14]

Source

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

resistivity	
Magnetic ordering	diamagnetic[4]
Young's modulus	8 GPa
Shear modulus	2.8 GPa
Bulk modulus	43 GPa
Poisson ratio	0.45
Mohs hardness	1.2
Brinell hardness	26.5–44.7 MPa
CAS Number	7440-28-0

History

Discovery	William Crookes (1861)
First isolation	Claude-Auguste Lamy (1862)

Most stable isotopes of thallium

iso	NA	half-life	DM	DE (MeV)	DP
^{203}Tl	29.5%	is stable with 122 neutrons			
^{204}Tl	syn	3.78 y	β^-	0.764	^{204}Pb
			ε	0.347	^{204}Hg
^{205}Tl	70.5%	is stable with 124 neutrons			