Silver

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Silver is the metallic element with the atomic number 47. Its symbol is **Ag**, from the Latin *argentum*, derived from the Greek ὰργὸς (literally "shiny" or "white"), and ultimately from a Proto-Indo-European language root reconstructed as *$h_2$erǵ-*, "grey" or "shining". A soft, white, lustrous transition metal, it exhibits the highest electrical conductivity, thermal conductivity, and reflectivity of any metal. The metal is found in the Earth's crust in the pure, free elemental form ("native silver"), as an alloy with gold and other metals, and in minerals such as argentite and chlorargyrite. Most silver is produced as a byproduct of copper, gold, lead, and zinc refining.

Silver has long been valued as a precious metal. Silver metal is used in many premodern monetary systems in bullion coins, sometimes alongside gold: while it is more abundant than gold, it is much less abundant as a native metal. Its purity is typically measured on a per mille basis; a 94%-pure alloy is described as "0.940 fine". As one of the seven metals of antiquity, silver has had an enduring role in most human cultures.

Silver is used in numerous applications other than currency, such as solar panels, water filtration, jewelry, ornaments, high-value tableware and utensils (hence the term silverware), and as an investment medium (coins and bullion). Silver is used industrially in electrical contacts and conductors, in specialized mirrors, window coatings, and in catalysis of chemical reactions. Silver compounds are used in photographic film and X-rays. Dilute silver nitrate solutions and other silver compounds are used as disinfectants and microbiocides (oligodynamic effect), added to bandages and wound-dressings, catheters, and other medical instruments.

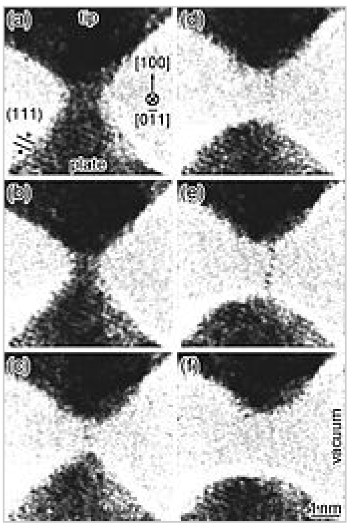
Silver, $_{47}$Ag

Electrolytically refined silver

General properties	
Name, symbol	silver, Ag
Appearance	lustrous white metal
Silver in the periodic table	
Atomic number (*Z*)	47
Group, block	group 11, d-block
Period	period 5
Element category	□ transition metal
Standard atomic weight (±) (A_r)	107.8682(2)[1]
Electron configuration	[Kr] $4d^{10}$ $5s^1$
per shell	2, 8, 18, 18, 1
Physical properties	
Phase	solid
Melting point	1234.93 K (961.78 °C, 1763.2 °F)

Characteristics

Silver is similar in its physical and chemical properties to its two vertical neighbours in group 11 of the periodic table, copper and gold. Its 47 electrons are arranged in the configuration $[Kr]4d^{10}5s^1$, similarly to copper ($[Ar]3d^{10}4s^1$) and gold ($[Xe]4f^{14}5d^{10}6s^1$); group 11 is one of the few groups in the d-block which has a completely consistent set of electron configurations.[4] This distinctive electron



Silver is extremely ductile, and can be drawn into a monoatomic wire.[3]

configuration, with a single electron in the highest occupied s subshell over a filled d subshell, accounts for many of the singular properties of metallic silver.[5]

Silver is an extremely soft, ductile and malleable transition metal, though it is slightly less malleable than gold. Silver crystallizes in a face-centered cubic lattice with bulk coordination number 12, where only the single 5s electron is delocalized, similarly to copper and gold.[6] Unlike metals with incomplete d-shells, metallic bonds in silver are lacking a covalent character and are relatively weak. This observation explains the low hardness and high ductility of single crystals of silver.[7]

Silver has a brilliant white metallic luster that can take a high polish,[8] and which is so characteristic that the name of the metal itself has become a colour name.[5] Unlike copper and gold, the energy required to excite an electron from the filled d band to the s-p conduction band in silver is large enough (around 385 kJ/mol) that it no longer corresponds to absorption in the visible region of the spectrum, but rather in the ultraviolet; hence silver is not a coloured metal.[5] Protected silver has greater optical reflectivity than aluminium at all wavelengths longer than ~450 nm.[9] At wavelengths shorter than 450 nm, silver's reflectivity is inferior to that of aluminium and drops to zero near 310 nm.[10]

Very high electrical and thermal conductivity is common to the elements in group 11, because their single s electron is free and does not interact with the filled d subshell, as such interactions (which occur in the preceding transition metals) lower electron mobility.[11] The electrical conductivity of silver is the greatest of all metals, greater even than copper, but it is not widely used for this property because of the higher cost. An exception is in radio-frequency engineering, particularly at VHF and higher frequencies where silver plating improves electrical conductivity because those currents tend to flow on the surface of conductors rather than through the interior. During World War II in the US, 13540 tons of silver were used in electromagnets for enriching uranium, mainly because of the wartime shortage of copper.[12][13][14] Pure

Boiling point	2435 K (2162 °C, 3924 °F)
Density near r.t.	10.49 g/cm^3
when liquid, at m.p.	9.320 g/cm^3
Heat of fusion	11.28 kJ/mol
Heat of vaporization	254 kJ/mol
Molar heat capacity	25.350 J/(mol·K)

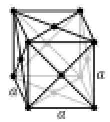
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1283	1413	1575	1782	2055	2433

Atomic properties

Oxidation states	−2, −1, **1**, 2, 3, 4 (an amphoteric oxide)
Electronegativity	Pauling scale: 1.93
Ionization energies	1st: 731.0 kJ/mol 2nd: 2070 kJ/mol 3rd: 3361 kJ/mol
Atomic radius	empirical: 144 pm
Covalent radius	145±5 pm
Van der Waals radius	172 pm

Miscellanea

Crystal structure	face-centered cubic (fcc) 
Speed of sound thin rod	2680 m/s (at r.t.)
Thermal expansion	18.9 µm/(m·K) (at 25 °C)

silver has the highest thermal conductivity of any metal, although the conductivity of carbon (in the diamond allotrope) and superfluid helium-4 are even higher.[4] Silver also has the lowest contact resistance of any metal.[4]

Silver readily forms alloys with copper and gold, as well as zinc. Zinc-silver alloys with low zinc concentration may be considered as face-centred cubic solid solutions of zinc in silver, as the structure of the silver is largely unchanged while the electron concentration rises as more zinc is added. Increasing the electron concentration further leads to body-centred cubic (electron concentration 1.5), complex cubic (1.615), and hexagonal close-packed phases (1.75).[6]

Isotopes

Naturally occurring silver is composed of two stable isotopes, ^{107}Ag and ^{109}Ag, with ^{107}Ag being slightly more abundant (51.839% natural abundance). This almost equal abundance is rare in the periodic table. The atomic weight is 107.8682(2) u;[15][16] this value is very important because of the importance of silver compounds, particularly halides, in gravimetric analysis.[1] Both isotopes of silver are produced in stars via the s-process (slow neutron capture), as well as in supernovas via the r-process (rapid neutron capture).[17]

Twenty-eight radioisotopes have been characterized, the most stable being ^{105}Ag with a half-life of 41.29 days, ^{111}Ag with a half-life of 7.45 days, and ^{112}Ag with a half-life of 3.13 hours. Silver has numerous nuclear isomers, the most stable being ^{108m}Ag ($t_{1/2}$ = 418 years), ^{110m}Ag ($t_{1/2}$ = 249.79 days) and ^{106m}Ag ($t_{1/2}$ = 8.28 days). All of the remaining radioactive isotopes have half-lives of less than an hour, and the majority of these have half-lives of less than three minutes.[18]

Isotopes of silver range in relative atomic mass from 92.950 u (^{93}Ag) to 129.950 u (^{130}Ag);[19] the primary decay mode before the most abundant stable isotope, ^{107}Ag, is electron capture and the primary mode after is beta decay. The primary decay

Thermal conductivity	429 W/(m·K)
Thermal diffusivity	174 mm^2/s (at 300 K)
Electrical resistivity	15.87 nΩ·m (at 20 °C)
Magnetic ordering	diamagnetic[2]
Young's modulus	83 GPa
Shear modulus	30 GPa
Bulk modulus	100 GPa
Poisson ratio	0.37
Mohs hardness	2.5
Vickers hardness	251 MPa
Brinell hardness	206–250 MPa
CAS Number	7440-22-4
History	
Discovery	before 5000 BC
Most stable isotopes of silver	

products before ^{107}Ag are palladium (element 46) isotopes, and the primary products after are cadmium (element 48) isotopes.[18]

The palladium isotope ^{107}Pd decays by beta emission to ^{107}Ag with a half-life of 6.5 million years. Iron meteorites are the only objects with a high-enough palladium-to-silver ratio to yield measurable variations in ^{107}Ag abundance. Radiogenic ^{107}Ag was first discovered in the Santa Clara meteorite in 1978.[20] The discoverers suggest the coalescence and differentiation of iron-cored small planets may have occurred 10 million years after a nucleosynthetic event. ^{107}Pd–^{107}Ag correlations observed in bodies that have clearly been melted since the accretion of the solar system must reflect the presence of unstable nuclides in the early solar system.[21]

iso	NA	half-life	DM	DE (MeV)	DP
^{105}Ag	syn	41.2 d	ε	–	^{105}Pd
			γ	0.344, 0.280, 0.644, 0.443	–
^{106m}Ag	syn	8.28 d	ε	–	^{106}Pd
			γ	0.511, 0.717, 1.045, 0.450	–
^{107}Ag	51.839%	is stable with 60 neutrons			
^{108m}Ag	syn	418 y	ε	–	^{108}Pd
			IT	0.109	^{108}Ag
			γ	0.433, 0.614, 0.722	–
^{109}Ag	48.161%	is stable with 62 neutrons			
^{111}Ag	syn	7.45 d	β^-	1.036, 0.694	^{111}Cd
			γ	0.342	–

Source

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