Silver

<table>
<thead>
<tr>
<th>Name, symbol, number</th>
<th>silver, Ag, 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pronunciation</td>
<td>/ˈsɪlvər/</td>
</tr>
<tr>
<td>Element category</td>
<td>transition metal</td>
</tr>
<tr>
<td>Group, period, block</td>
<td>11, 5, d</td>
</tr>
<tr>
<td>Standard atomic weight</td>
<td>107.8682</td>
</tr>
</tbody>
</table>
**Electron configuration**

\[
\text{[Kr]}\ 4d^{10}\ 5s^1 \\
2, 8, 18, 18, 1
\]

**History**

**Discovery**

before 5000 BC

**Physical properties**

**Phase**

solid

**Density (near r.t.)**

10.49 g·cm\(^{-3}\)

**Liquid density at m.p.**

9.320 g·cm\(^{-3}\)

**Melting point**

1234.93 K, 961.78 °C, 1763.2 °F

**Boiling point**

2435 K, 2162 °C, 3924 °F

**Heat of fusion**

11.28 kJ·mol\(^{-1}\)

**Heat of vaporization**

250.58 kJ·mol\(^{-1}\)

**Molar heat capacity**

25.350 J·mol\(^{-1}\)·K\(^{-1}\)

**Vapor pressure**

<table>
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<tr>
<th>P (Pa)</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1 k</th>
<th>10 k</th>
<th>100 k</th>
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</thead>
<tbody>
<tr>
<td>at T (K)</td>
<td>1283</td>
<td>1413</td>
<td>1575</td>
<td>1782</td>
<td>2055</td>
<td>2433</td>
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</tbody>
</table>

**Atomic properties**

**Oxidation states**

1, 2, 3 (amphoteric oxide)

**Electronegativity**

1.93 (Pauling scale)

**Ionization energies**

1st: 731.0 kJ·mol\(^{-1}\)

2nd: 2070 kJ·mol\(^{-1}\)

3rd: 3361 kJ·mol\(^{-1}\)

**Atomic radius**

144 pm

**Covalent radius**

145±5 pm

**Van der Waals radius**

172 pm

**Miscellanea**
<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Crystal structure</td>
<td>face-centered cubic</td>
</tr>
<tr>
<td>Magnetic ordering</td>
<td>diamagnetic [1]</td>
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<tr>
<td>Electrical resistivity</td>
<td>(20 °C) 15.87 nΩ·m</td>
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<tr>
<td>Thermal conductivity</td>
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<tr>
<td>Thermal diffusivity</td>
<td>(300 K) 174 mm²/s</td>
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<tr>
<td>Thermal expansion</td>
<td>(25 °C) 18.9 µm·m⁻¹ K⁻¹</td>
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<tr>
<td>Speed of sound (thin rod)</td>
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<tr>
<td>Young's modulus</td>
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<tr>
<td>Shear modulus</td>
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<td>Bulk modulus</td>
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</table>

### Most stable isotopes

Main article: Isotopes of silver
Silver is a chemical element with the chemical symbol Ag (Greek: άργυρος árguros, Latin: argentum, both from the Indo-European root *arg- for "grey" or "shining") and atomic number 47. A soft, white, lustrous transition metal, it possesses the highest electrical conductivity of any element and the highest thermal conductivity of any metal. The metal occurs naturally in its pure, free 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, used in currency coins, to make ornaments, jewelry, high-value tableware and utensils (hence the term silverware) and as an investment in the forms of coins and bullion. Silver metal is used industrially in electrical contacts and conductors, in mirrors and in catalysis of chemical reactions. Its compounds are used in photographic film and dilute silver nitrate solutions and other silver compounds are used as disinfectants and microbiocides (oligodynamic effect). While many medical antimicrobial uses of silver have been supplanted by antibiotics, further research into clinical potential continues.

### Characteristics

Silver is produced from lighter elements in the Universe through the r-process, a form of nuclear fusion believed to take place during certain types of supernova explosions. This produces many elements heavier than iron, of which silver is one.

Silver is a very ductile, malleable (slightly harder than gold), monovalent coinage metal, with a brilliant white metallic luster that can take a high degree of polish. It has the highest electrical conductivity of all metals, even higher than...
copper, but its greater cost has prevented it from being widely used in place of copper for electrical purposes. An exception to this is in radio-frequency engineering, particularly at VHF and higher frequencies, where silver plating to improve electrical conductivity of parts, including wires, is widely employed. During World War II in the US, 13,540 tons were used in the electromagnets used for enriching uranium, mainly because of the wartime shortage of copper.

Among metals, pure silver has the highest thermal conductivity (the nonmetal carbon in the form of diamond and superfluid helium II are higher) and one of the highest optical reflectivities. (Aluminium slightly outdoes silver in parts of the visible spectrum, and silver is a poor reflector of ultraviolet). Silver is the best conductor of heat and electricity of any metal on the periodic table. Silver also has the lowest contact resistance of any metal. Silver halides are photosensitive and are remarkable for their ability to record a latent image that can later be developed chemically. Silver is stable in pure air and water, but tarnishes when it is exposed to air or water containing ozone or hydrogen sulfide, the latter forming a black layer of silver sulfide which can be cleaned off with dilute hydrochloric acid. The most common oxidation state of silver is +1 (for example, silver nitrate, AgNO₃); the less common +2 compounds (for example, silver(II) fluoride, AgF₂), and the even less common +3 (for example, potassium tetrafluorosilicate(III), KAgF₄) and even +4 compounds (for example, potassium hexafluorosilicate(IV), K₂AgF₆) are also known.

Isotopes
Naturally occurring silver is composed of two stable isotopes, ¹⁰⁷Ag and ¹⁰⁹Ag, with ¹⁰⁷Ag being slightly more abundant (51.839% natural abundance). Silver's isotopes are almost equal in abundance, something which is rare in the periodic table. Silver's atomic weight is 107.8682(2) g/mol. Twenty-eight radioisotopes have been characterized, the most stable being ¹⁰⁵Ag with a half-life of 41.29 days, ¹¹¹Ag with a half-life of 7.45 days, and ¹¹²Ag with a half-life of 3.13 hours. This element has numerous meta states, the most stable being ¹⁰⁸ᵐAg (t₁⁄₂ = 418 years), ¹¹⁰ᵐAg (t₁⁄₂ = 249.79 days) and ¹⁰⁶ᵐAg (t₁⁄₂ = 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.

Isotopes of silver range in relative atomic mass from 93.943 (⁹⁴Ag) to 126.936 (¹²⁷Ag); the primary decay mode before the most abundant stable isotope, ¹⁰⁷Ag, is electron capture and the primary mode after is beta decay. The primary decay products before ¹⁰⁷Ag are palladium (element 46) isotopes, and the primary products after are cadmium (element 48) isotopes.

The palladium isotope ¹⁰⁷Pd decays by beta emission to ¹⁰⁷Ag 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 ¹⁰⁷Ag abundance. Radiogenic ¹⁰⁷Ag was first discovered in the Santa Clara meteorite in 1978. The discoverers suggest the coalescence and differentiation of iron-cored small planets may have occurred 10 million years after a nucleosynthetic event. ¹⁰⁷Pd–¹⁰⁷Ag 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.

Compounds
Silver metal dissolves readily in nitric acid (HNO₃) to produce silver nitrate (AgNO₃), a transparent crystalline solid that is photosensitive and readily soluble in water. Silver nitrate is used as the starting point for the synthesis of many other silver compounds, as an antiseptic, and as a yellow stain for glass in stained glass. Silver metal does not react with sulfuric acid, which is used in jewelry-making to clean and remove copper oxide firescale from silver articles after silver soldering or annealing. Silver reacts readily with sulfur or hydrogen sulfide (H₂S) to produce silver sulfide, a dark-colored compound familiar as the tarnish on silver coins and other objects. Silver sulfide Ag₂S
Silver chloride (AgCl) is precipitated from solutions of silver nitrate in the presence of chloride ions, and the other silver halides used in the manufacture of photographic emulsions are made in the same way, using bromide or iodide salts. Silver chloride is used in glass electrodes for pH testing and potentiometric measurement, and as a transparent cement for glass. Silver iodide has been used in attempts to seed clouds to produce rain. Silver halides are highly insoluble in aqueous solutions and are used in gravimetric analytical methods.

Silver oxide (Ag₂O), produced when silver nitrate solutions are treated with a base, is used as a positive electrode (anode) in watch batteries. Silver carbonate

\[
2 \text{AgNO}_3 + 2 \text{OH}^- \rightarrow \text{Ag}_2\text{O} + \text{H}_2\text{O} + 2 \text{NO}_3^-
\]

Silver fulminate (AgONC), a powerful, touch-sensitive explosive used in percussion caps, is made by reaction of silver metal with nitric acid in the presence of ethanol (C₂H₅OH). Other dangerously explosive silver compounds are silver azide (AgN₃), formed by reaction of silver nitrate with sodium azide (NaN₃)³⁻, and silver acetylide, formed when silver reacts with acetylene gas.

Latent images formed in silver halide crystals are developed by treatment with alkaline solutions of reducing agents such as hydroquinone, metol (4-(methylamino)phenol sulfate) or ascorbate, which reduce the exposed halide to silver metal. Alkaline solutions of silver nitrate can be reduced to silver metal by reducing sugars such as glucose, and this reaction is used to silver glass mirrors and the interior of glass Christmas ornaments. Silver halides are soluble in solutions of sodium thiosulfate (Na₂S₂O₃) which is used as a photographic fixer, to remove excess silver halide from photographic emulsions after image development.

Silver metal is attacked by strong oxidizers such as potassium permanganate (KMnO₄) and potassium dichromate (K₂Cr₂O₇), and in the presence of potassium bromide (KBr); these compounds are used in photography to bleach silver images, converting them to silver halides that can either be fixed with thiosulfate or redeveloped to intensify the original image. Silver forms cyanide complexes (silver cyanide) that are soluble in water in the presence of an excess of cyanide ions. Silver cyanide solutions are used in electroplating of silver.

Although silver normally has oxidation state +1 in compounds, other oxidation states are known, such as +3 in AgF₃, produced by the reaction of elemental silver or silver fluoride with krypton difluoride.
Applications

Many well-known uses of silver involve its precious metal properties, including currency, decorative items, and mirrors. The contrast between its bright white color and other media makes it very useful to the visual arts. It has also long been used to confer high monetary value as objects (such as silver coins and investment bars) or make objects symbolic of high social or political rank. Silver salts have been used since the Middle Ages to produce a yellow or orange colours to stained glass, and more complex decorative colour reactions can be produced by incorporating silver metal in blown, kilnformed or torchworked glass.

Currency

Silver, in the form of electrum (a gold–silver alloy), was coined to produce money around 700 BC by the Lydians. Later, silver was refined and coined in its pure form. Many nations used silver as the basic unit of monetary value. In the modern world, silver bullion has the ISO currency code XAG. The name of the pound sterling (£) reflects the fact it originally represented the value of one pound Tower weight of sterling silver; other historical currencies, such as the French livre, have similar etymologies. During the 19th century, the bimetallism that prevailed in most countries was undermined by the discovery of large deposits of silver in the Americas; fearing a sharp decrease in the value of silver and thus the currency, most states switched to a gold standard by 1900. In some languages, such as Sanskrit, Spanish, French, and Hebrew, the same word means both silver and money.

The 20th century saw a gradual movement to fiat currency, with most of the world monetary system losing its link to precious metals after Richard Nixon took the United States dollar off the gold standard in 1971; the last currency backed by gold was the Swiss franc, which became a pure fiat currency on 1 May 2000. During this same period, silver gradually ceased to be used in circulating coins. In 1964, the United States stopped minting their silver dime and quarter. They minted their last circulating silver coin in 1970 in its 40% half-dollar.

In 1968, Canada minted their last circulating silver coins which were the 50% dime and the 50% quarter. The Royal Canadian Mint still makes many collectible silver coins with various dollar denominations.

Silver is used as a currency by many individuals, and is legal tender in the US state of Utah. Silver coins and bullion are also used as an investment to guard against inflation and devaluation.

Jewelry and silverware

Jewelry and silverware are traditionally made from sterling silver (standard silver), an alloy of 92.5% silver with 7.5% copper. In the US, only an alloy consisting of at least 90.0% fine silver can be marketed as "silver" (thus frequently stamped 900). Sterling silver (stamped 925) is harder than pure silver, and has a lower melting point (893°C) than either pure silver or pure copper. Britannia silver is an alternative, hallmark-quality standard containing 95.8% silver, often used to make silver tableware and wrought plate. With the addition of germanium, the patented modified alloy Argentium Sterling silver is formed, with improved properties, including resistance to firescale.

Sterling silver jewelry is often plated with a thin coat of .999 fine silver to give the item a shiny finish. This process is called "flashing". Silver jewelry can also be plated with rhodium (for a bright, shiny look) or gold (to produce silver gilt).
Silver is a constituent of almost all colored carat gold alloys and carat gold solders, giving the alloys paler color and greater hardness. White 9 carat gold contains 62.5% silver and 37.5% gold, while 22 carat gold contains a minimum of 91.7% gold and 8.3% silver or copper or other metals.

Historically, the training and guild organization of goldsmiths included silversmiths, as well, and the two crafts remain largely overlapping. Unlike blacksmiths, silversmiths do not shape the metal while it is red-hot, but instead, work it at room temperature with gentle and carefully placed hammer blows. The essence of silversmithing is to take a flat piece of metal and to transform it into a useful object using different hammers, stakes and other simple tools.

While silversmiths specialize in, and principally work silver, they also work with other metals, such as gold, copper, steel, and brass. They make jewelry, silverware, armor, vases, and other artistic items. Because silver is such a malleable metal, silversmiths have a large range of choices with how they prefer to work the metal. Historically, silversmiths are mostly referred to as goldsmiths, which was usually the same guild. In the western Canadian silversmith tradition, guilds do not exist; however, mentoring through colleagues becomes a method of professional learning within a community of craftspeople.

Traditionally, silversmiths mostly made "silverware" (cutlery, tableware, bowls, candlesticks and such). Only in more recent times has silversmithing become mainly work in jewelry, as much less solid silver tableware is now handmade.

**Dentistry**

Silver can be alloyed with mercury at room temperature to make amalgams that are widely used for dental fillings. To make dental amalgam, a mixture of powdered silver and other metals such as tin and gold is mixed with mercury to make a stiff paste that can be adapted to the shape of a cavity. The dental amalgam achieves initial hardness within minutes, and sets hard in a few hours.

**Photography and electronics**

Photography used 30.98% of the silver consumed in 1998 in the form of silver nitrate and silver halides. In 2001, 23.47% was used for photography, while 20.03% was used in jewelry, 38.51% for industrial uses, and only 3.5% for coins and medals. The use of silver in photography has rapidly declined, due to the lower demand for consumer color film from the advent of digital technology; since 2007, of the 907 million ounces of silver in supply, just 117.6 million ounces (13%) were consumed by the photographic sector, about 50% of the amount used in photography in 1998. By 2010, the supply had increased by about 10% to 1056.8 million ounces, of which 72.7 million ounces were used in the photographic sector, a decline of 38% compared with 2007.

Some electrical and electronic products use silver for its superior conductivity, even when tarnished. The primary example of this is in high quality RF connectors. The increase in conductivity is also taken advantage of in RF engineering at VHF and higher frequencies, where conductors often cannot be scaled by 6%, due to tuning requirements, e.g. cavity filters. As an additional example, printed circuits and RFID antennas can be made using silver paints, and computer keyboards use silver electrical contacts. Silver cadmium oxide is used in high-voltage contacts because it can withstand arcing.

Some manufacturers produce audio connector cables, speaker wires, and power cables using silver conductors, which have a 6% higher conductivity than ordinary copper ones of identical dimensions, but cost much more. Though debatable, many hi-fi enthusiasts believe silver wires improve sound quality. [citation needed]
Small devices, such as hearing aids and watches, commonly use silver oxide batteries due to their long life and high energy-to-weight ratio. Another usage is high-capacity silver-zinc and silver-cadmium batteries.

**Mirrors and optics**

Mirrors which need superior reflectivity for visible light are commonly made with silver as the reflecting material in a process called silvering, though common mirrors are backed with aluminium. Using a process called sputtering, silver, along with other optically transparent layers, is applied to glass, creating low emissivity coatings used in high-performance insulated glazing. The amount of silver used per window is small because the silver layer is only 10–15 nanometers thick. However, the amount of silver-coated glass worldwide is hundreds of millions of square meters per year, leading to silver consumption on the order of 10 cubic meters or 100 metric tons/year. Silver color seen in architectural glass and tinted windows on vehicles is produced by sputtered chrome, stainless steel or other alloys. Silver is seldom used as the reflector in telescope mirrors, where aluminum is generally preferred because it is cheaper and less susceptible to tarnishing and corrosion. Silver is the reflective coating of choice for solar reflectors.

**Other industrial and commercial applications**

Silver and silver alloys are used in the construction of high-quality musical wind instruments of many types. Flutes, in particular, are commonly constructed of silver alloy or silver plated, both for appearance and for the frictional surface properties of silver. Silver's catalytic properties make it ideal for use as a catalyst in oxidation reactions, for example, the production of formaldehyde from methanol and air by means of silver screens or crystallites containing a minimum 99.95 weight-percent silver. Silver (upon some suitable support) is probably the only catalyst available today to convert ethylene to ethylene oxide (later hydrolyzed to ethylene glycol, used for making polyesters)—an important industrial reaction. It is also used in the Oddy test to detect reduced sulfur compounds and carbonyl sulfides.

Because silver readily absorbs free neutrons, it is commonly used to make control rods to regulate the fission chain reaction in pressurized water nuclear reactors, generally in the form of an alloy containing 80% silver, 15% indium, and 5% cadmium.

Silver is used to make solder and brazing alloys, and as a thin layer on bearing surfaces can provide a significant increase in galling resistance and reduce wear under heavy load, particularly against steel.
**Biology**

Silver stains are used in biology to increase the contrast and visibility of cells and organelles in microscopy. Camillo Golgi used silver stains to study cells of the nervous system and the Golgi apparatus. Silver stains are used to stain proteins in gel electrophoresis and polyacrylamide gels, either as primary stains or to enhance the visibility and contrast of colloidal gold stain.

**Medicine**

The **medical uses of silver** include its incorporation into wound dressings, and its use as an antibiotic coating in medical devices. Wound dressings containing silver sulfadiazine or silver nanomaterials may be used to treat external infections. Silver is also used in some medical applications, such as urinary catheters and endotracheal breathing tubes, where there is tentative evidence that it is effective in reducing catheter-related urinary tract infections and ventilator-associated pneumonia respectively. The silver ion (Ag\(^+\)) is bioactive and in sufficient concentration readily kills bacteria in vitro. Silver and silver nanoparticles are used as an antimicrobial in a variety of industrial, healthcare and domestic applications.

**Investing**

Silver coins and bullion are used for investing. Mints sell a wide variety of silver products for investors and collectors. Various institutions provide safe storage for large physical silver investments, and various types of silver investments can be made on the stock markets, including mining stocks. Silver bullion bars are sold in a wide range of ounces, provided by various mints and mines around the world. Silver coins and bullion bars are generally 99.9% pure, and labeled with ".999".

**Clothing**

Silver inhibits the growth of bacteria and fungi on clothing, such as socks, so is sometimes added to reduce odors and the risk of bacterial and fungal infections. It is incorporated into clothing or shoes either by integrating silver nanoparticles into the polymer from which yarns are made or by coating yarns with silver. The loss of silver during washing varies between textile technologies, and the resultant effect on the environment is not yet fully known.\(^4\)

**History**

Silver has been used for thousands of years for ornaments and utensils, trade, and as the basis for many monetary systems. Its value as a precious metal was long considered second only to gold. The word "silver" appears in Anglo-Saxon in various spellings, such as *seolfor* and *sioflor*. A similar form is seen throughout the Germanic languages (compare Old High German *silabar* and *silbir*). The chemical symbol Ag is from the Latin word for "silver", *argentum* (compare Greek ἀργυρός, ἄργυρος, from the Indo-European root *arg-, meaning "white" or "shining". Silver has been known since ancient times. Mentioned in the Book of Genesis, slag heaps found in Asia Minor and on the islands of the Aegean Sea indicate silver was being separated from lead as early as the 4th millennium BC using surface mining.

The stability of the Roman currency relied to a high degree on the supply of silver bullion, which Roman miners produced on a scale unparalleled before the discovery of the New World. Reaching a peak production of 200 t per year, an estimated silver stock of 10,000 t circulated in the Roman economy in the middle of the second century AD, five to ten times larger than the combined amount of silver available to medieval Europe and the Caliphate around 800 AD. Financial officials of the Roman Empire worried about the loss...
of silver to pay for highly demanded silk from Sinica (China).

Mines were made in Laureion during 483 BC.\[^{5}\]

In the Gospels, Jesus' disciple Judas Iscariot is infamous for having taken a bribe of 30 coins of silver from religious leaders in Jerusalem to turn Jesus of Nazareth over to soldiers of the High Priest Caiaphas.

The Chinese Empire during most of its history primarily used silver as a means of exchange. In the 19th century, the threat to the balance of payments of the United Kingdom from Chinese merchants demanding payment in silver in exchange for tea, silk, and porcelain led to the Opium War because Britain had to find a way to address the imbalance in payments, and they decided to do so by selling opium produced in their colony of British India to China.\[^{6}\]

Recorded use of silver to prevent infection dates to ancient Greece and Rome; it was rediscovered in the Middle Ages, when it was used for several purposes, such as to disinfect water and food during storage, and also for the treatment of burns and wounds as wound dressing. In the 19th century, sailors on long ocean voyages would put silver coins in barrels of water and wine to keep the liquid potable. Pioneers in America used the same idea as they made their journey from coast to coast. Silver solutions were approved in the 1920s by the US Food and Drug Administration for use as antibacterial agents.\[^{citation needed}\]

In certain circumstances, Islam permits Muslim men to wear silver jewelry.\[^{citation needed}\] Muhammad himself wore a silver signet ring.

In the Americas, high temperature silver-lead cupellation technology was developed by pre-Inca civilizations as early as AD 60–120.

**Folklore**

In European folklore, silver was considered a mystical element, and much like Cold Iron, was considered something of an anathema towards aspects of the supernatural. The myth of silver's mystical properties goes deep into human history. Silver is believed to have purifying effects, a belief that likely arose from the observation that water kept in a silver pitcher took longer to go scummy; in modern times, silver has been shown to have antibacterial properties.

As a noble metal akin to gold, this is often attributed to something along the lines of silver's "Incorruptible Pure Purenness". Due to the above, silver is almost always considered to be on the good end of magic (and items formed of it may also be "Made of Good"). In some traditions of Neopaganism, silver is the metal associated with the powers of the Moon, symbolizes the light of the moon, representing the feminine energies of the Triple Goddess. In Francis Barret's *The Magus*, it is said to make the bearer "amiable, pleasant, cheerful and honoured, removing all malice and ill-will; it causes security in a journey, increases the riches, and health of body drives away enemies..." In rituals, silver is said to encourage a harmonious energy and a sense of peace.

In folklore, and now later in fiction, the metal is said to do many things, from channel magic, to stopping evil (including warding off or harming vampires and werewolves), making magic mirrors, to turning water into a "Healing Potion". Throughout mythology and subsequent fiction, silver has been a common ward against evil. Silver, especially if blessed, was thought to ward off or harm certain supernatural beings (including vampires) since the Middle Ages.
World War II

During World War II, the short supply of copper led to the substitution of silver in many industrial applications. The United States government loaned out silver from its massive reserve located in the West Point vaults to a wide range of industrial users. One very important use was for bus bars for new aluminum plants needed to make aircraft. During the war, many electrical connectors and switches were silver plated. Another use was aircraft master rod bearings and other types of bearings. Since silver can replace tin in solder at a lower volume, a large amount of tin was freed up for other uses by substituting government silver. Silver was also used as the reflector in searchlights and other types of lights. One high-tech use of silver was for conductors at Oak Ridge National Laboratory used in calutrons to isolate uranium as part of the Manhattan project. (After the war ended, the silver was returned to the vaults.) Silver was used in nickels during the war to save that metal for use in steel alloys.

Occurrence and extraction

Silver is found in native form, as an alloy with gold (electrum), and in ores containing sulfur, arsenic, antimony or chlorine. Ores include argentite (Ag₂S), chlorargyrite (AgCl) which includes horn silver, and pyrargyrite (Ag₃SbS₃). The principal sources of silver are the ores of copper, copper-nickel, lead, and lead-zinc obtained from Peru, Bolivia, Mexico, China, Australia, Chile, Poland and Serbia. Peru, Bolivia and Mexico have been mining silver since 1546, and are still major world producers. Top silver-producing mines are Cannington (Australia), Fresnillo (Mexico), San Cristobal (Bolivia), Antamina (Peru), Rudna (Poland), and Penasquito (Mexico). Top near-term mine development projects through 2015 are Pascua Lama (Chile), Navidad (Argentina), Jaunipicio (Mexico), Malku Khota (Bolivia), and Hackett River (Canada). In Central Asia, Tajikistan is known to have some of the largest silver deposits in the world.

The metal is primarily produced as a byproduct of electrolytic copper refining, gold, nickel, and zinc refining, and by application of the Parkes process on lead metal obtained from lead ores that contain small amounts of silver. Commercial-grade fine silver is at least 99.9% pure, and purities greater than 99.999% are available. In 2011, Mexico was the top producer of silver (4,500 tonnes or 19% of the world's total), closely followed by Peru (4,000 t) and China (4,000 t).[7]
Price

As of 26 August 2013, the price of silver is US$773 per kilogram (US$24.04 per troy ounce\textsuperscript{[8]}). This equates to approximately 1/58 the price of gold. The ratio has varied from 1/15 to 1/100 in the past 100 years.\textsuperscript{[citation needed]} Physical silver bullion prices are higher than the paper prices, with premiums increasing when demand is high and local shortages occur.\textsuperscript{[9]}

In 1980, the silver price rose to a peak for modern times of US$49.45 per troy ounce (ozt) due to market manipulation of Nelson Bunker Hunt and Herbert Hunt. Inflation-adjusted to 2012, this is approximately US$138 per troy ounce. Some time after Silver Thursday, the price was back to $10/ozt. From 2001 to 2010, the price moved from $4.37 to $20.19 (average London US$/oz). According to the Silver Institute, silver's recent gains have greatly stemmed from a rise in investor interest and an increase in fabrication demand. In late April 2011, silver reached an all-time high of $49.76/ozt.

In earlier times, silver has commanded much higher prices. In the early 15th century, the price of silver is estimated to have surpassed $1,200 per ounce, based on 2011 dollars.\textsuperscript{[10]} The discovery of massive silver deposits in the New World during the succeeding centuries has been stated as a cause for its price to have diminished greatly.

The price of silver is important in Judaic law. The lowest fiscal amount a Jewish court, or Beth Din, can convene to adjudicate a case over is a shova pruta (value of a Babylonian pruta coin).\textsuperscript{[citation needed]} This is fixed at .025 grams (0.00088 oz) of pure, unrefined silver, at market price. In a Jewish tradition, still continuing today, on the first birthday of a first-born son, the parents pay the price of five pure-silver coins to a Kohen (priest). Today, the Israel mint fixes the coins at 117 grams (4.1 oz) of silver. The Kohen will often give those silver coins back as a gift for the child to inherit.\textsuperscript{[11]}

Human exposure and consumption

Silver plays no known natural biological role in humans, and possible health effects of silver are a disputed subject. Silver itself is not toxic to humans, but most silver salts are. In large doses, silver and compounds containing it can be absorbed into the circulatory system and become deposited in various body tissues, leading to argyria, which results in a blue-grayish pigmentation of the skin, eyes, and mucous membranes. Argyria is rare, and although, so far as known, this condition does not otherwise harm a person's health, it is disfiguring and usually permanent. Mild forms of Argria are sometimes mistaken for cyanosis.

Monitoring exposure

Overexposure to silver can occur in workers in the metallurgical industry, persons taking silver-containing dietary supplements, patients who have received silver sulfadiazine treatment, and individuals who accidentally or intentionally ingest silver salts. Silver concentrations in whole blood, plasma, serum, or urine may be measured to monitor for safety in exposed workers, to confirm the diagnosis in potential poisoning victims, or to assist in the forensic investigation in a case of fatal overdosage.\textsuperscript{[12]}
Use in food

Silver is used in food coloring; it has the E174 designation and is approved in the European Union. The safety of silver for use in food is disputed. Traditional Indian dishes sometimes include the use of decorative silver foil known as vark, and in various cultures, silver dragée are used to decorate cakes, cookies, and other dessert items. The use of silver as a food additive is not approved in the United States.[citation needed]

References

[1] Magnetic susceptibility of the elements and inorganic compounds (http://www-d0.fnal.gov/hardware/cal/lvps_info/engineering/elementmagn.pdf) in
[11] Living Judaism: the complete guide to Jewish belief, tradition, Wayne D. Dosick – 1995 “The price was set at five shekalim (the plural of shekel, the monetary unit of the time) for each of the 273 extra firstborn (Numbers 3:47). The money was given to Aaron, the High Priest, the head of the tribe of Levi.”

External links

• Chemistry in its element podcast (http://www.rsc.org/chemistryworld/podcast/element.asp) (MP3) from the Royal Society of Chemistry's Chemistry World: Silver (http://www.rsc.org/images/CIIE_silver_48kbpstcm18-118748.mp3)
• Silver (http://www.periodicvideos.com/videos/047.htm) at The Periodic Table of Videos (University of Nottingham)
• Society of American Silversmiths (http://www.silversmithing.com/)
• The Silver Institute (http://www.silverinstitute.org/) A silver industry website
• A collection of silver items (http://www.theodoregray.com/PeriodicTable/Elements/047/index.html) Samples of silver
• Transport, Fate and Effects of Silver in the Environment (http://digital.library.wisc.edu/1711.dl/EcoNatRes.Argentum)
• CDC – NIOSH Pocket Guide to Chemical Hazards – Silver (http://www.cdc.gov/niosh/npg/npgd0557.html)
• Picture in the Element collection from Heinrich Pniok (http://www.pniok.de/ag.htm)
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