Copper

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Copper is a chemical element with symbol **Cu** (from Latin: *cuprum*) and atomic number 29. It is a soft, malleable and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a reddish-orange color. It is used as a conductor of heat and electricity, as a building material and as a constituent of various metal alloys, such as sterling silver used in jewelry, cupronickel used to make marine hardware and coins and constantan used in strain gauges and thermocouples for temperature measurement.

Copper is found as a pure metal in nature, and this was the first source of the metal to be used by humans, c. 8000 BC. It was the first metal to be smelted from its ore, c. 5000 BC, the first metal to be cast into a shape in a mold, c. 4000 BC and the first metal to be purposefully alloyed with another metal, tin, to create bronze, c. 3,500 BC.[3]

In the Roman era, copper was principally mined on Cyprus, the origin of the name of the metal, from *aes cyprium* (metal of Cyprus), later corrupted to *cuprum*, from which the words *copper* (English), *cuivre* (French), *Koper* (Dutch) and *Kupfer* (German) are all derived.[4] The commonly encountered compounds are copper(II) salts, which often impart blue or green colors to such minerals as azurite, malachite, and turquoise, and have been used widely and historically as pigments. Architectural structures built with copper (usually roofing elements) corrode to give green verdigris (or patina). Decorative art prominently features copper, both in the elemental metal and in compounds as pigments. Copper compounds are also used as bacteriostatic agents, fungicides, and wood preservatives.

Copper is essential to all living organisms as a trace dietary mineral because it is a key constituent of the respiratory enzyme complex cytochrome c oxidase. In molluscs and crustaceans copper is a constituent of the blood pigment hemocyanin, replaced by the iron-complexed hemoglobin in fish and other vertebrates. In humans, copper is found mainly in the liver, muscle, and bone.[5] The adult body contains between 1.4 and 2.1 mg of copper per kilogram of body weight. Hence a healthy human weighing 60 kilogram contains approximately 0.1 g of copper. However, this small amount is essential to the overall human well-being.[6]

Copper, $_{29}$Cu

Native copper (~4 cm in size)

General properties	
Name, symbol	copper, Cu
Appearance	red-orange metallic luster
Copper in the periodic table	
Atomic number (Z)	29
Group, block	group 11, d-block
Period	period 4
Element category	□ transition metal
Standard atomic weight (±) (A_r)	63.546(3)[1]
Electron configuration	[Ar] $3d^{10}$ $4s^1$
per shell	2, 8, 18, 1
Physical properties	

Characteristics

Physical

A copper disc (99.95% pure) made by continuous casting; etched to reveal crystallites.

Copper just above its melting point keeps its pink luster color when enough light outshines the orange incandescence color.

Copper, silver and gold are in group 11 of the periodic table, and they share certain attributes: they have one s-orbital electron on top of a filled d-electron shell and are characterized by high ductility and electrical and thermal conductivity. The filled d-shells in these elements contribute little to interatomic interactions, which are dominated by the s-electrons through metallic bonds. Unlike metals with incomplete d-shells, metallic bonds in copper are lacking a covalent character and are relatively weak. This observation explains the low hardness and high ductility of single crystals of copper.[7] At the macroscopic scale, introduction of extended defects to the crystal lattice, such as grain boundaries, hinders flow of the material under applied stress, thereby increasing its hardness. For this reason, copper is usually supplied in a fine-grained polycrystalline form, which has greater strength than monocrystalline forms.[8]

The softness of copper partly explains its high electrical conductivity (59.6×10^6 S/m) and high thermal conductivity, the second highest (second only to silver) among pure metals at room temperature.[9] This is because the resistivity to electron transport in metals at room temperature originates primarily from scattering of electrons on thermal vibrations of the lattice, which are relatively weak in a soft metal.[7] The maximum permissible current density of copper in open air is approximately 3.1×10^6 A/m^2 of cross-sectional area, above which it begins to heat excessively.[10]

Copper is one of four metallic elements with a natural color other than gray or silver, the others being caesium (yellow), gold (yellow), and osmium (bluish).[11] Pure copper is orange-red and acquires a reddish tarnish when exposed to air. The characteristic color of copper results from

Phase	solid
Melting point	1357.77 K (1084.62 °C, 1984.32 °F)
Boiling point	2835 K (2562 °C, 4643 °F)
Density near r.t.	8.96 g/cm^3
when liquid, at m.p.	8.02 g/cm^3
Heat of fusion	13.26 kJ/mol
Heat of vaporization	300.4 kJ/mol
Molar heat capacity	24.440 J/(mol·K)

Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1509	1661	1850	2089	2404	2834

Atomic properties

Oxidation states	−2, +1, **+2**, +3, +4 (a mildly basic oxide)
Electronegativity	Pauling scale: 1.90
Ionization energies	1st: 745.5 kJ/mol 2nd: 1957.9 kJ/mol 3rd: 3555 kJ/mol (more)
Atomic radius	empirical: 128 pm
Covalent radius	132±4 pm
Van der Waals radius	140 pm

Miscellanea

Crystal structure	face-centered cubic (fcc)

the electronic transitions between the filled 3d and half-empty 4s atomic shells – the energy difference between these shells corresponds to orange light. The same mechanism causes the yellow color of gold and caesium.[7]

As with other metals, if copper is put in contact with another metal, galvanic corrosion will occur.[12]

Chemical

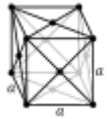
Copper does not react with water but it does slowly react with atmospheric oxygen to form a layer of brown-black copper oxide which, unlike the rust that forms on iron in moist air, protects the underlying metal from further corrosion (passivation). A green layer of verdigris (copper carbonate) can often be seen on old copper structures, such as the roofing of many older buildings[13] and the Statue of Liberty.[14] Copper tarnishes when exposed to some sulfur compounds, with which it reacts to form various copper sulfides.[15]

Isotopes

There are 29 isotopes of copper. ^{63}Cu and ^{65}Cu are stable, with ^{63}Cu comprising approximately 69% of naturally occurring copper; both have a spin of $^{3}/_{2}$.[16] The other isotopes are radioactive, with the most stable being ^{67}Cu with a half-life of 61.83 hours.[16] Seven metastable isotopes have been characterized; ^{68m}Cu is the longest-lived with a half-life of 3.8 minutes. Isotopes with a mass number above 64 decay by β^-, whereas those with a mass number below 64 decay by β^+. ^{64}Cu, which has a half-life of 12.7 hours, decays both ways.[17]

^{62}Cu and ^{64}Cu have significant applications. ^{62}Cu is used in ^{62}Cu-PTSM as a radioactive tracer for positron emission tomography.[18]

Occurrence



Speed of sound thin rod	(annealed) 3810 m/s (at r.t.)
Thermal expansion	16.5 µm/(m·K) (at 25 °C)
Thermal conductivity	401 W/(m·K)
Electrical resistivity	16.78 nΩ·m (at 20 °C)
Magnetic ordering	diamagnetic[2]
Young's modulus	110–128 GPa
Shear modulus	48 GPa
Bulk modulus	140 GPa
Poisson ratio	0.34
Mohs hardness	3.0
Vickers hardness	343–369 MPa
Brinell hardness	235–878 MPa
CAS Number	7440-50-8
History	
Naming	after Cyprus, principal mining place in Roman era (*Cyprium*)
Discovery	Middle East (9000 BCE)

Most stable isotopes of copper

Copper is produced in massive stars[19] and is present in the Earth's crust in a proportion of about 50 parts per million (ppm).[20] It occurs as native copper, in the copper sulfides chalcopyrite and chalcocite, in the copper carbonates azurite and malachite, and in the copper(I) oxide mineral cuprite.[9] The largest mass of elemental copper discovered weighed 420 tonnes and was found in 1857 on the Keweenaw Peninsula in Michigan, US.[20] Native copper is a polycrystal, with the largest single crystal ever described measuring 4.4×3.2×3.2 cm.[21]

iso	NA	half-life	DM	DE (MeV)	DP
^{63}Cu	69.15%	is stable with 34 neutrons			
^{64}Cu	syn	12.700 h	ε	–	^{64}Ni
			β^-	–	^{64}Zn
^{65}Cu	30.85%	is stable with 36 neutrons			
^{67}Cu	syn	61.83 h	β^-	–	^{67}Zn

Source

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