Aluminium

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Aluminium or **aluminum** (in North American English) is a chemical element in the boron group with symbol **Al** and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal. Aluminium is the third most abundant element in the Earth's crust (after oxygen and silicon) and its most abundant metal. Aluminium makes up about 8% of the crust by mass, though it is less common in the mantle below. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.[7] The chief ore of aluminium is bauxite.

Aluminium is remarkable for the metal's low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and structures, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminium.

Despite its prevalence in the environment, no known form of life uses aluminium salts metabolically, but aluminium is well tolerated by plants and animals.[8] Because of these salts' abundance, the potential for a biological role for them is of continuing interest, and studies continue.

Aluminium, $_{13}$Al

Spectral lines of aluminium

General properties	
Name, symbol	aluminium, Al
Alternative name	aluminum (US)
Appearance	silvery gray metallic
Aluminium in the periodic table	
Atomic number (Z)	13
Group, block	group 13, p-block
Period	period 3
Element category	post-transition metal, sometimes considered a metalloid
Standard atomic weight (±) (A_r)	26.9815385(7)[1]

Characteristics

Physical

Aluminium is a relatively soft, durable, lightweight, ductile, and malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. It is nonmagnetic and does not easily ignite. A fresh film of aluminium serves as a good reflector (approximately 92%) of visible light and an excellent reflector (as much as 98%) of medium and far infrared radiation. The yield strength of pure aluminium is 7–11 MPa, while aluminium alloys have yield strengths ranging from 200 MPa to 600 MPa.[9] Aluminium has about one-third the density and stiffness of steel. It is easily machined, cast, drawn and extruded.

Aluminium atoms are arranged in a face-centered cubic (fcc) structure. Aluminium has a stacking-fault energy of approximately 200 mJ/m^2.[10]

Aluminium is a good thermal and electrical conductor, having 59% the conductivity of copper, both thermal and electrical, while having only 30% of copper's density. Aluminium is capable of superconductivity, with a superconducting critical temperature of 1.2 kelvin and a critical magnetic field of about 100 gauss (10 milliteslas).[11] Aluminium is the most common material for the fabrication of superconducting qubits.[12]

Chemical

Corrosion resistance can be excellent because a thin surface layer of aluminium oxide forms when the bare metal is exposed to air, effectively preventing further oxidation,[13] in a process termed passivation. The strongest aluminium alloys are less corrosion resistant due to galvanic reactions with alloyed copper.[9] This corrosion resistance is greatly reduced by aqueous salts, particularly in the presence of dissimilar metals.

In highly acidic solutions, aluminium reacts with water to form hydrogen, and in highly alkaline ones to form aluminates— protective passivation under these conditions is negligible. Primarily because it is corroded by dissolved chlorides, such as common sodium chloride, household plumbing is never made from aluminium.[14]

However, because of its general resistance to corrosion, aluminium is one of the few metals that retains silvery reflectance in finely powdered form, making it an important component of silver-colored paints. Aluminium mirror finish has the highest reflectance of any metal in the 200–400 nm (UV) and the 3,000–10,000 nm (far IR) regions; in the 400–700 nm visible range it is slightly outperformed by tin and silver and in the 700–3000 nm (near IR) by silver, gold, and copper.[15]

Aluminium is oxidized by water at temperatures below 280 °C to produce hydrogen, aluminium hydroxide and heat:

$$2\,Al + 6\,H_2O \rightarrow 2\,Al(OH)_3 + 3\,H_2$$

Electron configuration	[Ne] $3s^2\ 3p^1$
per shell	2, 8, 3
Physical properties	
Phase	solid
Melting point	933.47 K (660.32 °C, 1220.58 °F)
Boiling point	2743 K (2470 °C, 4478 °F)
Density near r.t.	2.70 g/cm^3
when liquid, at m.p.	2.375 g/cm^3
Heat of fusion	10.71 kJ/mol
Heat of vaporization	284 kJ/mol
Molar heat capacity	24.20 J/(mol·K)

Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1482	1632	1817	2054	2364	2790

Atomic properties	
Oxidation states	**+3**, +2,[2] +1[3], −1, −2 (an amphoteric oxide)
Electronegativity	Pauling scale: 1.61
Ionization energies	1st: 577.5 kJ/mol 2nd: 1816.7 kJ/mol 3rd: 2744.8 kJ/mol (more)
Atomic radius	empirical: 143 pm
Covalent radius	121±4 pm
Van der Waals radius	184 pm
Miscellanea	

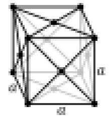
This conversion is of interest for the production of hydrogen. However, commercial application of this fact has challenges in circumventing the passivating oxide layer, which inhibits the reaction, and in storing the energy required to regenerate the aluminium metal.[16]

Isotopes

Aluminium has many known isotopes, with mass numbers range from 21 to 42; however, only ^{27}Al (stable) and ^{26}Al (radioactive, $t_{1/2} = 7.2\times10^5$ years) occur naturally. ^{27}Al has a natural abundance above 99.9%. ^{26}Al is produced from argon in the atmosphere by spallation caused by cosmic-ray protons. Aluminium isotopes are useful in dating marine sediments, manganese nodules, glacial ice, quartz in rock exposures, and meteorites. The ratio of ^{26}Al to ^{10}Be has been used to study transport, deposition, sediment storage, burial times, and erosion on 10^5 to 10^6 year time scales.[17] Cosmogenic ^{26}Al was first applied in studies of the Moon and meteorites. Meteoroid fragments, after departure from their parent bodies, are exposed to intense cosmic-ray bombardment during their travel through space, causing substantial ^{26}Al production. After falling to Earth, atmospheric shielding drastically reduces ^{26}Al production, and its decay can then be used to determine the meteorite's terrestrial age. Meteorite research has also shown that ^{26}Al was relatively abundant at the time of formation of our planetary system. Most meteorite scientists believe that the energy released by the decay of ^{26}Al was responsible for the melting and differentiation of some asteroids after their formation 4.55 billion years ago.[18]

Natural occurrence

Stable aluminium is created when hydrogen fuses with magnesium, either in large stars or in supernovae.[19] It is estimated to be the 14th most common element in the Universe, by mass-fraction.[20] However, among the elements that have odd atomic numbers, aluminium is the third most abundant by mass fraction, after hydrogen and nitrogen.[20]

Crystal structure	face-centered cubic (fcc) 
Speed of sound thin rod	(rolled) 5000 m/s (at r.t.)
Thermal expansion	23.1 µm/(m·K) (at 25 °C)
Thermal conductivity	237 W/(m·K)
Electrical resistivity	28.2 nΩ·m (at 20 °C)
Magnetic ordering	paramagnetic[4]
Magnetic susceptibility (χ)	$+16.5\cdot10^{-6}$ cm^3/mol
Young's modulus	70 GPa
Shear modulus	26 GPa
Bulk modulus	76 GPa
Poisson ratio	0.35
Mohs hardness	2.75
Vickers hardness	160–350 MPa
Brinell hardness	160–550 MPa
CAS Number	7429-90-5
History	
Prediction	Antoine Lavoisier[5] (1787)
First isolation	Hans Christian Ørsted[6] (1825)
Named by	Humphry Davy[5] (1807)
Most stable isotopes of aluminium	

iso	NA	half-life	DM	DE (MeV)	DP
^{26}**Al**	trace	7.17×10^{5} y	β^{+}	1.17	^{26}Mg
			ε	–	^{26}Mg
			γ	1.8086	–
^{27}**Al**	100%	is stable with 14 neutrons			

In the Earth's crust, aluminium is the most abundant (8.3% by mass) metallic element and the third most abundant of all elements (after oxygen and silicon).[21] The Earth's crust has a greater abundance of aluminium than the rest of the planet, primarily in aluminium silicates. In the Earths mantle, which is only 2% aluminium by mass, these aluminium silicate minerals are largely replaced by silica and magnesium oxides. Overall, the Earth is about 1.4% aluminium by mass (eighth in abundance by mass). Aluminium occurs in greater proportion in the Earth than in the Solar system and Universe because the more common elements (hydrogen, helium, neon, nitrogen, carbon as hydrocarbon) are volatile at Earth's proximity to the Sun and large quantities of those were lost.

Because of its strong affinity for oxygen, aluminium is almost never found in the elemental state; instead it is found in oxides or silicates. Feldspars, the most common group of minerals in the Earth's crust, are aluminosilicates. Native aluminium metal can only be found as a minor phase in low oxygen fugacity environments, such as the interiors of certain volcanoes.[22] Native aluminium has been reported in cold seeps in the northeastern continental slope of the South China Sea. Chen *et al.* (2011)[23] propose the theory that these deposits resulted from bacterial reduction of tetrahydroxoaluminate $Al(OH)_4^-$.[23]

Aluminium also occurs in the minerals beryl, cryolite, garnet, spinel, and turquoise. Impurities in Al_2O_3, such as chromium and iron, yield the gemstones ruby and sapphire, respectively.

Although aluminium is a common and widespread element, not all aluminium minerals are economically viable sources of the metal. Almost all metallic aluminium is produced from the ore bauxite ($AlO_x(OH)_{3-2x}$). Bauxite occurs as a weathering product of low iron and silica bedrock in tropical climatic conditions.[24] Bauxite is mined from large deposits in Australia, Brazil, Guinea, and Jamaica; it is also mined from lesser deposits in China, India, Indonesia, Russia, and Suriname.

Source

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