Tungsten

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Tungsten, also known as **wolfram**, is a chemical element with symbol **W** and atomic number 74. The word *tungsten* comes from the Swedish language *tung sten*, which directly translates to *heavy stone*.[4] Its name in Swedish is *volfram*, however, in order to distinguish it from scheelite, which is alternatively named *tungsten* in Swedish.

A hard, rare metal under standard conditions when uncombined, tungsten is found naturally on Earth almost exclusively in chemical compounds. It was identified as a new element in 1781, and first isolated as a metal in 1783. Its important ores include wolframite and scheelite. The free element is remarkable for its robustness, especially the fact that it has the highest melting point of all the elements. Its high density is 19.3 times that of water, comparable to that of uranium and gold, and much higher (about 1.7 times) than that of lead.[5] Polycrystalline tungsten is an intrinsically brittle[6][7] and hard material, making it difficult to work. However, pure single-crystalline tungsten is more ductile, and can be cut with a hard-steel hacksaw.[8]

Tungsten's many alloys have numerous applications, including incandescent light bulb filaments, X-ray tubes (as both the filament and target), electrodes in TIG welding, superalloys, and radiation shielding. Tungsten's hardness and high density give it military applications in penetrating projectiles. Tungsten compounds are also often used as industrial catalysts.

Tungsten is the only metal from the third transition series that is known to occur in biomolecules, where it is used in a few species of bacteria and archaea. It is the heaviest element known to be essential to any living organism.[9] Tungsten interferes with molybdenum and copper metabolism and is somewhat toxic to animal life.[10][11]

Tungsten, $_{74}$W

General properties	
Name, symbol	tungsten, W
Alternative name	wolfram
Appearance	grayish white, lustrous
Tungsten in the periodic table	
Atomic number (*Z*)	74
Group, block	group 6, d-block
Period	period 6
Element category	transition metal
Standard atomic weight (±) (A_r)	183.84(1)[1]
Electron configuration	[Xe] $4f^{14}$ $5d^4$ $6s^2$[2]
per shell	2, 8, 18, 32, 12, 2
Physical properties	
Phase	solid
Melting point	3695 K (3422 °C, 6192 °F)
Boiling point	6203 K (5930 °C, 10,706 °F)
Density near r.t.	19.25 g/cm^3
when liquid, at m.p.	

Characteristics

Physical properties

In its raw form, tungsten is a hard steel-grey metal that is often brittle and hard to work. If made very pure, tungsten retains its hardness (which exceeds that of many steels), and becomes malleable enough that it can be worked easily.[8] It is worked by forging, drawing, or extruding. Tungsten objects are also commonly formed by sintering.

Of all metals in pure form, tungsten has the highest melting point (3422 °C, 6192 °F), lowest vapor pressure (at temperatures above 1650 °C, 3000 °F) and the highest tensile strength.[12] Although carbon remains solid at higher temperatures than tungsten, carbon sublimes, rather than melts, so tungsten is considered to have a higher melting point. Tungsten has the lowest coefficient of thermal expansion of any pure metal. The low thermal expansion and high melting point and tensile strength of tungsten originate from strong covalent bonds formed between tungsten atoms by the 5d electrons.[13] Alloying small quantities of tungsten with steel greatly increases its toughness.[5]

Tungsten exists in two major crystalline forms: α and β. The former has a body-centered cubic structure and is the more stable form. The structure of the β phase is called A15 cubic; it is metastable, but can coexist with the α phase at ambient conditions owing to non-equilibrium synthesis or stabilization by impurities. Contrary to the α phase which crystallizes in isometric grains, the β form exhibits a columnar habit. The α phase has one third of the electrical resistivity[14] and a much lower superconducting transition temperature T_C relative to the β phase: ca. 0.015 K vs. 1–4 K; mixing the two phases allows obtaining intermediate T_C values.[15][16] The T_C value can also be raised by alloying tungsten with another metal (e.g. 7.9 K for W-Tc).[17] Such tungsten alloys are sometimes used in low-temperature superconducting circuits.[18][19][20]

Isotopes

Naturally occurring tungsten consists of five isotopes whose half-lives are so long that they can be considered stable. Theoretically, all five can decay into isotopes of element 72 (hafnium) by alpha emission, but only ^{180}W has been

	17.6 g/cm^3
Heat of fusion	35.3 kJ/mol
Heat of vaporization	774 kJ/mol
Molar heat capacity	24.27 J/(mol·K)

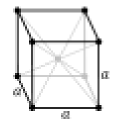
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	3477	3773	4137	4579	5127	5823

Atomic properties

Oxidation states	**6**, 5, **4**, 3, 2, 1, 0, −1, −2, −4 (a mildly acidic oxide)
Electronegativity	Pauling scale: 2.36
Ionization energies	1st: 770 kJ/mol 2nd: 1700 kJ/mol
Atomic radius	empirical: 139 pm
Covalent radius	162±7 pm

Miscellanea

Crystal structure	body-centered cubic (bcc) 
Speed of sound thin rod	4620 m/s (at r.t.) (annealed)
Thermal expansion	4.5 µm/(m·K) (at 25 °C)
Thermal conductivity	173 W/(m·K)
Electrical resistivity	52.8 nΩ·m (at 20 °C)
Magnetic ordering	paramagnetic[3]
Young's modulus	411 GPa

observed[21][22] to do so with a half-life of $(1.8 \pm 0.2)\times10^{18}$ years; on average, this yields about two alpha decays of ^{180}W in one gram of natural tungsten per year.[23] The other naturally occurring isotopes have not been observed to decay, constraining their half-lives to be at least 4×10^{21} years.

Another 30 artificial radioisotopes of tungsten have been characterized, the most stable of which are ^{181}W with a half-life of 121.2 days, ^{185}W with a half-life of 75.1 days, ^{188}W with a half-life of 69.4 days, ^{178}W with a half-life of 21.6 days, and ^{187}W with a half-life of 23.72 h.[23] All of the remaining radioactive isotopes have half-lives of less than 3 hours, and most of these have half-lives below 8 minutes.[23] Tungsten also has 4 meta states, the most stable being ^{179m}W ($t_{1/2}$ 6.4 minutes).

Chemical properties

Elemental tungsten resists attack by oxygen, acids, and alkalis.[24]

The most common formal oxidation state of tungsten is +6, but it exhibits all oxidation states from −2 to +6.[24][25] Tungsten typically combines with oxygen to form the yellow tungstic oxide, WO_3, which dissolves in aqueous alkaline solutions to form tungstate ions, WO_4^{2-}.

Tungsten carbides (W_2C and WC) are produced by heating powdered tungsten with carbon. W_2C is resistant to chemical attack, although it reacts strongly with chlorine to form tungsten hexachloride (WCl_6).[5]

Shear modulus	161 GPa
Bulk modulus	310 GPa
Poisson ratio	0.28
Mohs hardness	7.5
Vickers hardness	3430–4600 MPa
Brinell hardness	2000–4000 MPa
CAS Number	7440-33-7
History	
Discovery	Carl Wilhelm Scheele (1781)
First isolation	Juan José Elhuyar and Fausto Elhuyar (1783)
Named by	Torbern Bergman (1781)

Most stable isotopes of tungsten

iso	NA	half-life	DM	DE (MeV)	DP
^{180}W	0.12%	1.8×10^{18} y	α	2.516	^{176}Hf
^{181}W	syn	121.2 d	ε	0.188	^{181}Ta
^{182}W	26.50%	is stable with 108 neutrons			
^{183}W	14.31%	is stable with 110 neutrons			
^{184}W	30.64%	is stable with 111 neutrons			
^{185}W	syn	75.1 d	β^-	0.433	^{185}Re
^{186}W	28.43%	is stable with 112 neutrons			

In aqueous solution, tungstate gives the heteropoly acids and polyoxometalate anions under neutral and acidic conditions. As tungstate is progressively treated with acid, it first yields the soluble, metastable "paratungstate A" anion, $W_7O_{24}^{6-}$, which over time converts to the less soluble "paratungstate B" anion, $H_2W_{12}O_{42}^{10-}$.[26] Further acidification produces the very soluble metatungstate anion, $H_2W_{12}O_{40}^{6-}$, after which equilibrium is reached. The metatungstate ion exists as a symmetric cluster of twelve tungsten-oxygen octahedra known as the Keggin anion. Many other polyoxometalate anions exist as metastable species. The inclusion of a different atom such as phosphorus in place of the two central hydrogens in metatungstate produces a wide variety of heteropoly acids, such as phosphotungstic acid $H_3PW_{12}O_{40}$.

Tungsten trioxide can form intercalation compounds with alkali metals. These are known as *bronzes*; an example is sodium tungsten bronze.

External links

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