Titanium

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Titanium is a chemical element with symbol **Ti** and atomic number 22. It is a lustrous transition metal with a silver color, low density and high strength. It is highly resistant to corrosion in sea water, aqua regia, and chlorine.

Titanium was discovered in Cornwall, Great Britain, by William Gregor in 1791 and named by Martin Heinrich Klaproth for the Titans of Greek mythology. The element occurs within a number of mineral deposits, principally rutile and ilmenite, which are widely distributed in the Earth's crust and lithosphere, and it is found in almost all living things, rocks, water bodies, and soils.[3] The metal is extracted from its principal mineral ores by the Kroll[4] and Hunter processes. The most common compound, titanium dioxide, is a popular photocatalyst and is used in the manufacture of white pigments.[5] Other compounds include titanium tetrachloride ($TiCl_4$), a component of smoke screens and catalysts; and titanium trichloride ($TiCl_3$), which is used as a catalyst in the production of polypropylene.[3]

Titanium can be alloyed with iron, aluminium, vanadium, and molybdenum, among other elements, to produce strong, lightweight alloys for aerospace (jet engines, missiles, and spacecraft), military, industrial process (chemicals and petro-chemicals, desalination plants, pulp, and paper), automotive, agri-food, medical prostheses, orthopedic implants, dental and endodontic instruments and files, dental implants, sporting goods, jewelry, mobile phones, and other applications.[3]

The two most useful properties of the metal are corrosion resistance and the highest strength-to-density ratio of any metallic element.[6] In its unalloyed condition, titanium is as strong as some steels, but less dense.[7] There are two allotropic forms[8] and five naturally occurring isotopes of this element, ^{46}Ti through ^{50}Ti, with ^{48}Ti being the most abundant (73.8%).[9] Although they have the same number of valence electrons and are in the same group in the periodic table, titanium and zirconium differ in many chemical and physical properties.

Titanium, $_{22}Ti$

General properties	
Name, symbol	titanium, Ti
Appearance	silvery grey-white metallic
Titanium in the periodic table	
Atomic number (*Z*)	22
Group, block	group 4, d-block
Period	period 4
Element category	transition metal
Standard atomic weight (±) (A_r)	47.867(1)[1]
Electron configuration	[Ar] $3d^2$ $4s^2$
per shell	2, 8, 10, 2
Physical properties	
Phase	solid
Melting point	1941 K (1668 °C, 3034 °F)
Boiling point	3560 K (3287 °C, 5949 °F)

Characteristics

Physical properties

A metallic element, titanium is recognized for its high strength-to-weight ratio.[8] It is a strong metal with low density that is quite ductile (especially in an oxygen-free environment),[3] lustrous, and metallic-white in color.[10] The relatively high melting point (more than 1,650 °C or 3,000 °F) makes it useful as a refractory metal. It is paramagnetic and has fairly low electrical and thermal conductivity.[3]

Commercial (99.2% pure) grades of titanium have ultimate tensile strength of about 434 MPa (63,000 psi), equal to that of common, low-grade steel alloys, but are less dense. Titanium is 60% denser than aluminium, but more than twice as strong[7] as the most commonly used 6061-T6 aluminium alloy. Certain titanium alloys (e.g., Beta C) achieve tensile strengths of over 1400 MPa (200000 psi).[11] However, titanium loses strength when heated above 430 °C (806 °F).[12]

Titanium is not as hard as some grades of heat-treated steel, is non-magnetic and a poor conductor of heat and electricity. Machining requires precautions, because the material might gall if sharp tools and proper cooling methods are not used. Like those made from steel, titanium structures have a fatigue limit that guarantees longevity in some applications.[10] Titanium alloys have less stiffness than many other structural materials such as aluminium alloys and carbon fiber.

The metal is a dimorphic allotrope of an hexagonal α form that changes into a body-centered cubic (lattice) β form at 882 °C (1,620 °F).[12] The specific heat of the α form increases dramatically as it is heated to this transition temperature but then falls and remains fairly constant for the β form regardless of temperature.[12] Similar to zirconium and hafnium, an additional omega phase exists, which is thermodynamically stable at high pressures, but is metastable at ambient pressures. This phase is usually hexagonal (*ideal*) or trigonal (*distorted*) and can be considered to be due to a soft longitudinal acoustic phonon of the β phase causing collapse of (111) planes of atoms.[13]

Chemical properties

Density near r.t.	4.506 g/cm^3
when liquid, at m.p.	4.11 g/cm^3
Heat of fusion	14.15 kJ/mol
Heat of vaporization	425 kJ/mol
Molar heat capacity	25.060 J/(mol·K)

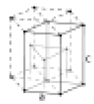
Vapor pressure

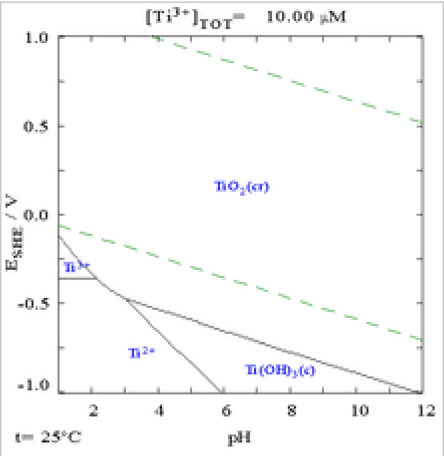
P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1982	2171	(2403)	2692	3064	3558

Atomic properties

Oxidation states	**4**, 3, 2, 1, −1, −2[2] (an amphoteric oxide)
Electronegativity	Pauling scale: 1.54
Ionization energies	1st: 658.8 kJ/mol 2nd: 1309.8 kJ/mol 3rd: 2652.5 kJ/mol (more)
Atomic radius	empirical: 147 pm
Covalent radius	160±8 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	5090 m/s (at r.t.)
Thermal expansion	8.6 µm/(m·K) (at 25 °C)
Thermal conductivity	21.9 W/(m·K)
Electrical resistivity	420 nΩ·m (at 20 °C)



The Pourbaix diagram for titanium in pure water, perchloric acid or sodium hydroxide[14]

Like aluminium and magnesium, titanium metal and its alloys oxidize immediately upon exposure to air. Titanium readily reacts with oxygen at 1,200 °C (2,190 °F) in air, and at 610 °C (1,130 °F) in pure oxygen, forming titanium dioxide.[8] It is, however, slow to react with water and air at ambient temperatures because it forms a passive oxide coating that protects the bulk metal from further oxidation.[3] When it first forms, this protective layer is only 1–2 nm thick but continues to grow slowly; reaching a thickness of 25 nm in four years.[15]

Atmospheric passivation gives titanium excellent resistance to corrosion, almost equivalent to platinum, capable of withstanding attack by dilute sulfuric and hydrochloric acids, chloride solutions, and most organic acids.[4] However, titanium is corroded by concentrated acids.[16] As indicated by its negative redox potential, titanium is thermodynamically a very reactive metal that burns in normal atmosphere at lower temperatures than the melting point. Melting is possible only in an inert atmosphere or in a vacuum. At 550 °C (1,022 °F), it combines with chlorine.[4] It also reacts with the other halogens and absorbs hydrogen.[5]

Titanium is one of the few elements that burns in pure nitrogen gas, reacting at 800 °C (1,470 °F) to form titanium nitride, which causes embrittlement.[17] Because of its high reactivity with oxygen, nitrogen, and some other gases, titanium filaments are applied in titanium sublimation pumps as scavengers for these gases. Such pumps inexpensively and reliably produce extremely low pressures in ultra-high vacuum systems.

Magnetic ordering	paramagnetic
Young's modulus	116 GPa
Shear modulus	44 GPa
Bulk modulus	110 GPa
Poisson ratio	0.32
Mohs hardness	6.0
Vickers hardness	830–3420 MPa
Brinell hardness	716–2770 MPa
CAS Number	7440-32-6
History	
Discovery	William Gregor (1791)
First isolation	Jöns Jakob Berzelius (1825)
Named by	Martin Heinrich Klaproth (1795)

Most stable isotopes of titanium

iso	NA	half-life	DM	DE (MeV)	DP
^{44}Ti	syn	63 y	ε	–	^{44}Sc
			γ	0.07D, 0.08D	–
^{46}Ti	8.25%	is stable with 24 neutrons			
^{47}Ti	7.44%	is stable with 25 neutrons			
^{48}Ti	73.72%	is stable with 26 neutrons			
^{49}Ti	5.41%	is stable with 27 neutrons			
^{50}Ti	5.18%	is stable with 28 neutrons			

Occurrence

Titanium is the ninth-most abundant element in Earth's crust (0.63% by mass)[19] and the seventh-most abundant metal. It is present as oxides in most igneous rocks, in sediments derived from them, in living things, and natural bodies of water.[3][4] Of the 801 types of igneous rocks analyzed by the United States Geological Survey, 784 contained titanium. Its proportion in soils is approximately 0.5 to 1.5%.[19]

It is widely distributed and occurs primarily in the minerals anatase, brookite, ilmenite, perovskite, rutile and titanite (sphene).[15] Of these minerals, only rutile and ilmenite have economic importance, yet even they are difficult to find in high concentrations. About 6.0 and 0.7 million tonnes of those minerals were mined in 2011, respectively.[18] Significant titanium-bearing ilmenite deposits exist in western Australia, Canada, China, India, Mozambique, New Zealand, Norway, Ukraine and South Africa.[15] About 186,000 tonnes of titanium metal sponge were produced in 2011, mostly in China (60,000 t), Japan (56,000 t), Russia (40,000 t), United States (32,000 t) and Kazakhstan (20,700 t). Total reserves of titanium are estimated to exceed 600 million tonnes.[18]

The concentration of Ti is about 4 picomolar in the ocean. At 100 °C, the concentration of titanium in water is estimated to be less than 10^{-7} M at pH 7. The identity of titanium species in aqueous solution remains unknown because of its low solubility and the lack of sensitive spectroscopic methods, although only the 4+ oxidation state is stable in air. No evidence exists for a biological role, although rare organisms are known to accumulate high concentrations of titanium.[20]

Titanium is contained in meteorites and has been detected in the Sun and in M-type stars[4] (the coolest type) with a surface temperature of 3,200 °C (5,790 °F).[21] Rocks brought back from the Moon during the Apollo 17 mission are composed of 12.1% TiO_2.[4] It is also found in coal ash, plants, and even the human body. Native titanium (pure metallic) is very rare.[22]

Isotopes

Naturally occurring titanium is composed of 5 stable isotopes: ^{46}Ti, ^{47}Ti, ^{48}Ti, ^{49}Ti, and ^{50}Ti, with ^{48}Ti being the most abundant (73.8% natural abundance). Eleven radioisotopes have been characterized, the most stable being ^{44}Ti with a half-life of 63 years; ^{45}Ti, 184.8 minutes; ^{51}Ti, 5.76 minutes; and ^{52}Ti, 1.7 minutes. All the other radioactive isotopes have half-lives less than 33 seconds and the majority, less than half a second.[9]

The isotopes of titanium range in atomic weight from 39.99 u (^{40}Ti) to 57.966 u (^{58}Ti). The primary decay mode before the most abundant stable isotope, ^{48}Ti, is electron capture and the primary mode after is beta emission. The primary decay products before ^{48}Ti are element 21 (scandium) isotopes and the primary products after are element 23 (vanadium) isotopes.[9]

Titanium becomes radioactive upon bombardment with deuterons, emitting mainly positrons and hard gamma rays.[4]

External links

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