Cadmium

From Wikipedia, the free encyclopedia

Cadmium is a chemical element with symbol **Cd** and atomic number 48. This soft, bluish-white metal is chemically similar to the two other stable metals in group 12, zinc and mercury. Like zinc, it demonstrates oxidation state +2 in most of its compounds, and like mercury, it has a lower melting point than other transition metals. Cadmium and its congeners are not always considered transition metals, in that they do not have partly filled *d* or *f* electron shells in the elemental or common oxidation states. The average concentration of cadmium in Earth's crust is between 0.1 and 0.5 parts per million (ppm). It was discovered in 1817 simultaneously by Stromeyer and Hermann, both in Germany, as an impurity in zinc carbonate.

Cadmium occurs as a minor component in most zinc ores and is a byproduct of zinc production. Cadmium was used for a long time as a corrosion-resistant plating on steel, and cadmium compounds are used as red, orange and yellow pigments, to colour glass, and to stabilize plastic. Cadmium use is generally decreasing because it is toxic (it is specifically listed in the European Restriction of Hazardous Substances[3]) and nickel-cadmium batteries have been replaced with nickel-metal hydride and lithium-ion batteries. One of its few new uses is cadmium telluride solar panels.

Although cadmium has no known biological function in higher organisms, a cadmium-dependent carbonic anhydrase has been found in marine diatoms.

Characteristics

Physical properties

Cadmium is a soft, malleable, ductile, bluish-white divalent metal. It is similar in many respects to zinc but forms complex compounds.[4] Unlike most other metals, cadmium is resistant to corrosion and is used as a protective plate on other metals. As a bulk metal, cadmium is insoluble in water and is not flammable; however, in its powdered form it may burn and release toxic fumes.[5]

Cadmium, $_{48}$Cd

General properties	
Name, symbol	cadmium, Cd
Appearance	silvery bluish-gray metallic
Cadmium in the periodic table	
Atomic number (*Z*)	48
Group, block	group 12, d-block
Period	period 5
Element category	□ transition metal, alternatively considered a post-transition metal
Standard atomic weight (±) (A_r)	112.414(4)[1]
Electron configuration	[Kr] $4d^{10}$ $5s^2$
per shell	2, 8, 18, 18, 2
Physical properties	
Phase	solid
Melting point	594.22 K (321.07 °C, 609.93 °F)

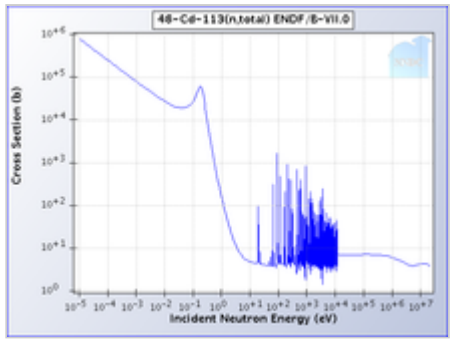
Chemical properties

Although cadmium usually has an oxidation state of +2, it also exists in the +1 state. Cadmium and its congeners are not always considered transition metals, in that they do not have partly filled d or f electron shells in the elemental or common oxidation states.[6] Cadmium burns in air to form brown amorphous cadmium oxide (CdO); the crystalline form of this compound is a dark red which changes color when heated, similar to zinc oxide. Hydrochloric acid, sulfuric acid, and nitric acid dissolve cadmium by forming cadmium chloride ($CdCl_2$), cadmium sulfate ($CdSO_4$), or cadmium nitrate ($Cd(NO_3)_2$). The oxidation state +1 can be produced by dissolving cadmium in a mixture of cadmium chloride and aluminium chloride, forming the Cd_2^{2+} cation, which is similar to the Hg_2^{2+} cation in mercury(I) chloride.[4]

$$Cd + CdCl_2 + 2\ AlCl_3 \rightarrow Cd_2(AlCl_4)_2$$

The structures of many cadmium complexes with nucleobases, amino acids, and vitamins have been determined.[7]

Isotopes



The cadmium-113 total cross section clearly showing the cadmium cut-off

Naturally occurring cadmium is composed of 8 isotopes. Two of them are radioactive, and three are expected to decay but have not done so under laboratory conditions. The two natural radioactive isotopes are ^{113}Cd (beta decay, half-life is 7.7×10^{15} years) and ^{116}Cd (two-neutrino double beta decay, half-life is 2.9×10^{19} years). The other three are ^{106}Cd, ^{108}Cd (both double electron capture), and ^{114}Cd (double beta decay); only lower limits on these half-lives have been determined. At least three isotopes – ^{110}Cd, ^{111}Cd, and ^{112}Cd – are stable. Among the isotopes that do not occur

Boiling point	1040 K (767 °C, 1413 °F)
Density near r.t.	8.65 g/cm^3
when liquid, at m.p.	7.996 g/cm^3
Heat of fusion	6.21 kJ/mol
Heat of vaporization	99.87 kJ/mol
Molar heat capacity	26.020 J/(mol·K)

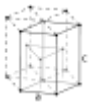
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	530	583	654	745	867	1040

Atomic properties

Oxidation states	**2**, 1, −2 (a mildly basic oxide)
Electronegativity	Pauling scale: 1.69
Ionization energies	1st: 867.8 kJ/mol 2nd: 1631.4 kJ/mol 3rd: 3616 kJ/mol
Atomic radius	empirical: 151 pm
Covalent radius	144±9 pm
Van der Waals radius	158 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	2310 m/s (at 20 °C)
Thermal expansion	30.8 µm/(m·K) (at 25 °C)
Thermal conductivity	96.6 W/(m·K)

naturally, the most long-lived are ^{109}Cd with a half-life of 462.6 days, and ^{115}Cd with a half-life of 53.46 hours. All of the remaining radioactive isotopes have half-lives of less than 2.5 hours, and the majority have half-lives of less than 5 minutes. Cadmium has 8 known meta states, with the most stable being ^{113m}Cd ($t_{1/2}$ = 14.1 years), ^{115m}Cd ($t_{1/2}$ = 44.6 days), and ^{117m}Cd ($t_{1/2}$ = 3.36 hours).[8]

The known isotopes of cadmium range in atomic mass from 94.950 u (^{95}Cd) to 131.946 u (^{132}Cd). For isotopes lighter than 112 u, the primary decay mode is electron capture and the dominant decay product is element 47 (silver). Heavier isotopes decay mostly through beta emission producing element 49 (indium).[8]

One isotope of cadmium, ^{113}Cd, absorbs neutrons with high selectivity: With very high probability, neutrons with energy below the *cadmium cut-off* will be absorbed; those higher than the *cut-off will be transmitted*. The cadmium cut-off is about 0.5 eV, and neutrons below that level are deemed slow neutrons, distinct from intermediate and fast neutrons.[9]

Cadmium is created via the long s-process in low-medium mass stars with masses of 0.6 to 10 solar masses, taking thousands of years. In that process, a silver atom captures a neutron and then undergoes beta decay.[10]

External links

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

Electrical resistivity	72.7 nΩ·m (at 22 °C)
Magnetic ordering	diamagnetic[2]
Young's modulus	50 GPa
Shear modulus	19 GPa
Bulk modulus	42 GPa
Poisson ratio	0.30
Mohs hardness	2.0
Brinell hardness	203–220 MPa
CAS Number	7440-43-9
History	
Discovery and first isolation	Karl Samuel Leberecht Hermann and Friedrich Stromeyer (1817)
Named by	Friedrich Stromeyer (1817)
Most stable isotopes of cadmium	

iso	NA	half-life	DM	DE (MeV)	DP
^{106}Cd	1.25%	is stable with 58 neutrons			
^{107}Cd	syn	6.5 h	ε	1.417	^{107}Ag
^{108}Cd	0.89%	is stable with 60 neutrons			
^{109}Cd	syn	462.6 d	ε	0.214	^{109}Ag
^{110}Cd	12.47%	is stable with 62 neutrons			
^{111}Cd	12.80%	is stable with 63 neutrons			
^{112}Cd	24.11%	is stable with 64 neutrons			
^{113}Cd	12.23%	7.7×10^{15} y	β−	0.316	^{113}In
^{113m}Cd	syn	14.1 y	β−	0.580	^{113}In
			IT	0.264	^{113}Cd
^{114}Cd	28.75%	is stable with 66 neutrons			
^{115}Cd	syn	53.46 h	β−	1.446	^{115}In
^{116}Cd	7.51%	3.1×10^{19} y	β−β−	2.809	^{116}Sn