Osmium

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Osmium (from Greek ὀσμή *osme*, "smell") is a chemical element with symbol **Os** and atomic number 76. It is a hard, brittle, bluish-white transition metal in the platinum group that is found as a trace element in alloys, mostly in platinum ores. Osmium is the densest naturally occurring element, with a density of 22.59 g/cm^3. Its alloys with platinum, iridium, and other platinum-group metals are employed in fountain pen nib tipping, electrical contacts, and other applications where extreme durability and hardness are needed.[3]

Characteristics

Physical properties

Osmium, remelted pellet

Osmium has a blue-gray tint and is the densest stable element, slightly denser than iridium.[4] Calculations of density from the X-ray diffraction data may produce the most reliable data for these elements, giving a value of 22.562 ± 0.009 g/cm^3 for iridium versus 22.587 ± 0.009 g/cm^3 for osmium.[5]

Osmium is a hard but brittle metal that remains lustrous even at high temperatures. It has a very low compressibility. Correspondingly, its bulk modulus is extremely high, reported between 395 and 462 GPa, which rivals that of diamond (443 GPa). The hardness of osmium is moderately high at 4 GPa.[6][7][8] Because of its hardness, brittleness, low vapor pressure (the lowest of the platinum-group metals), and very high melting point (the fourth highest of all elements), solid osmium is difficult to machine, form, or work.

Osmium, $_{76}$Os

General properties	
Name, symbol	osmium, Os
Appearance	silvery, blue cast
Osmium in the periodic table	
Atomic number (*Z*)	76
Group, block	group 8, d-block
Period	period 6
Element category	transition metal
Standard atomic weight (±) (A_r)	190.23(3)[1]
Electron configuration	[Xe] $4f^{14}\ 5d^6\ 6s^2$
per shell	2, 8, 18, 32, 14, 2
Physical properties	
Phase	solid
Melting point	3306 K (3033 °C, 5491 °F)
Boiling point	5285 K (5012 °C, 9054 °F)
Density near r.t.	22.59 g/cm^3
when liquid, at m.p.	

Chemical properties

Osmium forms compounds with oxidation states ranging from −2 to +8. The most common oxidation states are +2, +3, +4, and +8. The +8 oxidation state is notable for being the highest attained by any chemical element aside from iridium's +9[9] and is encountered only in xenon,[10][11] ruthenium,[12] hassium,[13] and iridium.[14] The oxidation states −1 and −2 represented by the two reactive compounds $Na_2[Os_4(CO)_{13}]$ and $Na_2[Os(CO)_4]$ are used in the synthesis of osmium cluster compounds.[15][16]

Oxidation states of osmium	
−2	$Na_2[Os(CO)_4]$
−1	$Na_2[Os_4(CO)_{13}]$
0	$Os_3(CO)_{12}$
+1	OsI
+2	OsI_2
+3	$OsBr_3$
+4	OsO_2, $OsCl_4$
+5	OsF_5
+6	OsF_6
+7	$OsOF_5$
+8	OsO_4, $Os(NCH_3)_4$

The most common compound exhibiting the +8 oxidation state is osmium tetroxide. This toxic compound is formed when powdered osmium is exposed to air. It is a very volatile, water-soluble, pale yellow, crystalline solid with a strong smell. Osmium powder has the characteristic smell of osmium tetroxide.[17] Osmium tetroxide forms red osmates $OsO_4(OH)_2^{2-}$ upon reaction with a base. With ammonia, it forms the nitrido-osmates OsO_3N^-.[18][19][20] Osmium tetroxide boils at 130 °C and is a powerful oxidizing agent. By contrast, osmium dioxide (OsO_2) is black, non-volatile, and much less reactive and toxic.

Only two osmium compounds have major applications: osmium tetroxide for staining tissue in electron microscopy and for the oxidation of alkenes in organic synthesis, and the non-volatile osmates for organic oxidation reactions.[21]

	20 g/cm^3
Heat of fusion	31 kJ/mol
Heat of vaporization	378 kJ/mol
Molar heat capacity	24.7 J/(mol·K)

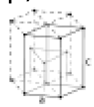
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	3160	3423	3751	4148	4638	5256

Atomic properties

Oxidation states	8, 7, 6, 5, **4**, 3, 2, 1, 0, −1, −2, −4 (a mildly acidic oxide)
Electronegativity	Pauling scale: 2.2
Ionization energies	1st: 840 kJ/mol 2nd: 1600 kJ/mol
Atomic radius	empirical: 135 pm
Covalent radius	144±4 pm

Miscellanea

Crystal structure	hexagonal close-packed (hcp) 
Speed of sound thin rod	4940 m/s (at 20 °C)
Thermal expansion	5.1 µm/(m·K) (at 25 °C)
Thermal conductivity	87.6 W/(m·K)
Electrical resistivity	81.2 nΩ·m (at 0 °C)
Magnetic ordering	paramagnetic[2]
Shear modulus	222 GPa
Bulk modulus	462 GPa

Osmium pentafluoride (OsF_5) is known, but osmium trifluoride (OsF_3) has not yet been synthesized. The lower oxidation states are stabilized by the larger halogens, so that the trichloride, tribromide, triiodide, and even diiodide are known. The oxidation state +1 is known only for osmium iodide (OsI), whereas several carbonyl complexes of osmium, such as triosmium dodecacarbonyl ($Os_3(CO)_{12}$), represent oxidation state 0.[18][19][22][23]

In general, the lower oxidation states of osmium are stabilized by ligands that are good σ-donors (such as amines) and π-acceptors (heterocycles containing nitrogen). The higher oxidation states are stabilized by strong σ- and π-donors, such as O^{2-} and N^{3-}.[24]

Despite its broad range of compounds in numerous oxidation states, osmium in bulk form at ordinary temperatures and pressures resists attack by all acids and alkalis, including aqua regia.[25]

Poisson ratio	0.25
Mohs hardness	7.0
Brinell hardness	3490–4000 MPa
CAS Number	7440-04-2
History	
Discovery and first isolation	Smithson Tennant (1803)

Most stable isotopes of osmium

iso	NA	half-life	DM	DE (MeV)	DP
^{184}**Os**	0.02%	is stable with 108 neutrons			
^{185}**Os**	syn	93.6 d	ε	1.013	^{185}Re
^{186}**Os**	1.59%	2.0×10^{15} y	α	2.822	^{182}W
^{187}**Os**	1.96%	is stable with 111 neutrons			
^{188}**Os**	13.24%	is stable with 112 neutrons			
^{189}**Os**	16.15%	is stable with 113 neutrons			
^{190}**Os**	26.26%	is stable with 114 neutrons			
^{191}**Os**	syn	15.4 d	β^-	0.314	^{191}Ir
^{192}**Os**	40.78%	is stable with 116 neutrons			
^{193}**Os**	syn	30.11 d	β^-	1.141	^{193}Ir
^{194}**Os**	syn	6 y	β^-	0.097	^{194}Ir

Isotopes

Osmium has seven naturally occurring isotopes, six of which are stable: ^{184}Os, ^{187}Os, ^{188}Os, ^{189}Os, ^{190}Os, and (most abundant) ^{192}Os. ^{186}Os undergoes alpha decay with such a long half-life $(2.0 \pm 1.1) \times 10^{15}$ years, approximately 140 000 times the age of the universe, that for practical purposes it can be considered stable. Alpha decay is predicted for all seven naturally occurring isotopes, but it has been observed only for ^{186}Os, presumably due to very long half-lives. It is predicted that ^{184}Os and ^{192}Os can undergo double beta decay but this radioactivity has not been observed yet.[26]

^{187}Os is the daughter of ^{187}Re (half-life 4.56×10^{10} years) and is used extensively in dating terrestrial as well as meteoric rocks (see rhenium-osmium dating). It has also been used to measure the intensity of continental weathering over geologic time and to fix minimum ages for stabilization of the mantle roots of continental cratons. This decay is a reason why rhenium-rich minerals are abnormally rich in ^{187}Os.[27] However, the most notable application of Os isotopes in geology has been in conjunction with the abundance of iridium, to characterise the layer of shocked quartz along the Cretaceous–Paleogene boundary that marks the extinction of the dinosaurs 66 million years ago.[28]

Source

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