Selenium

From Wikipedia, the free encyclopedia

Selenium is a chemical element with symbol **Se** and atomic number 34. It is a nonmetal with properties that are intermediate between the elements above and below in the periodic table, sulfur and tellurium. It rarely occurs in its elemental state or as pure ore compounds in the Earth's crust. Selenium (Greek σελήνη *selene* meaning "Moon") was discovered in 1817 by Jöns Jacob Berzelius, who noted the similarity of the new element to the previously discovered tellurium (named for the Earth).

Selenium is found in metal sulfide ores, where it partially replaces the sulfur. Commercially, selenium is produced as a byproduct in the refining of these ores, most often during production. Minerals that are pure selenide or selenate compounds are known but rare. The chief commercial uses for selenium today are glassmaking and pigments. Selenium is a semiconductor and is used in photocells. Applications in electronics, once important, have been mostly supplanted by silicon semiconductor devices. Selenium is still used in a few types of DC power surge protectors and one type of fluorescent quantum dot.

Selenium salts are toxic in large amounts, but trace amounts are necessary for cellular function in many organisms, including all animals. Selenium is an ingredient in many multivitamins and other dietary supplements, including infant formula. It is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certain oxidized molecules in animals and some plants). It is also found in three deiodinase enzymes, which convert one thyroid hormone to another. Selenium requirements in plants differ by species, with some plants requiring relatively large amounts and others apparently requiring none.[4]

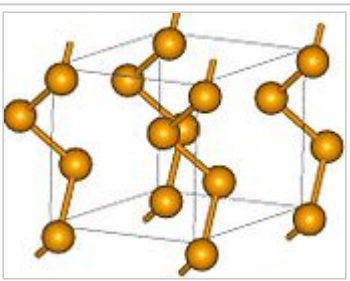
Selenium, $_{34}$Se

General properties	
Name, symbol	selenium, Se
Appearance	black, red, and gray (not pictured) allotropes
Selenium in the periodic table	
Atomic number (Z)	34
Group, block	group 16 (chalcogens), p-block
Period	period 4
Element category	▯ polyatomic nonmetal, sometimes considered a metalloid
Standard atomic weight (±) (A_r)	78.971(8)[1]
Electron configuration	[Ar] $3d^{10}$ $4s^2$ $4p^4$
per shell	2, 8, 18, 6
Physical properties	

Characteristics

Physical properties

Selenium forms several allotropes that interconvert with temperature changes, depending somewhat on the rate of temperature change. When prepared in chemical reactions, selenium is usually an amorphous, brick-red powder. When



Structure of hexagonal (gray) selenium

rapidly melted, it forms the black, vitreous form, usually sold commercially as beads.[5] The structure of black selenium is irregular and complex and consists of polymeric rings with up to 1000 atoms per ring. Black Se is a brittle, lustrous solid that is slightly soluble in CS_2. Upon heating, it softens at 50 °C and converts to gray selenium at 180 °C; the transformation temperature is reduced by presence of halogens and amines.[6]

The red α, β, and γ forms are produced from solutions of black selenium by varying the evaporation rate of the solvent (usually CS_2). They all have relatively low, monoclinic crystal symmetries and contain nearly identical puckered Se_8 rings with different arrangements, as in sulfur. The packing is most dense in the α form. In the Se_8 rings, the Se-Se distance is 233.5 pm and Se-Se-Se angle is 105.7°. Other selenium allotropes may contain Se_6 or Se_7 rings.[6]

The most stable and dense form of selenium is gray and has a hexagonal crystal lattice consisting of helical polymeric chains, where the Se-Se distance is 237.3 pm and Se-Se-Se angle is 130.1°. The minimum distance between chains is 343.6 pm. Gray Se is formed by mild heating of other allotropes, by slow cooling of molten Se, or by condensing Se vapor just below the melting point. Whereas other Se forms are insulators, gray Se is a semiconductor showing appreciable photoconductivity. Unlike the other allotropes, it is insoluble in CS_2.[6] It resists oxidation by air and is not attacked by nonoxidizing acids. With strong reducing agents, it forms polyselenides. Selenium does not exhibit the changes in viscosity that sulfur undergoes when gradually heated.[5][7]

Isotopes

Selenium has six naturally occurring isotopes. Synthetic isotope ^{79}Se and 23 others have been identified:

Phase	solid
Melting point	494 K (221 °C, 430 °F)
Boiling point	958 K (685 °C, 1265 °F)
Density near r.t.	gray: 4.81 g/cm^3 alpha: 4.39 g/cm^3 vitreous: 4.28 g/cm^3
when liquid, at m.p.	3.99 g/cm^3
Critical point	1766 K, 27.2 MPa
Heat of fusion	gray: 6.69 kJ/mol
Heat of vaporization	95.48 kJ/mol
Molar heat capacity	25.363 J/(mol·K)

Vapor pressure

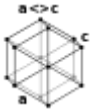
P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	500	552	617	704	813	958

Atomic properties

Oxidation states	**6**, 5, **4**, 3, **2**, 1,[2] −1, **−2** (a strongly acidic oxide)
Electronegativity	Pauling scale: 2.55
Ionization energies	1st: 941.0 kJ/mol 2nd: 2045 kJ/mol 3rd: 2973.7 kJ/mol
Atomic radius	empirical: 120 pm
Covalent radius	120±4 pm
Van der Waals radius	190 pm

Miscellanea

Crystal structure	hexagonal



^{82}Se is stable, for all practical purposes. See also *Selenium-79* for recent changes in the measured half-life of ^{79}Se, which are important for the dose calculations in the geological disposal of long-lived radioactive waste.[10]

External links

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

Speed of sound thin rod	3350 m/s (at 20 °C)
Thermal expansion	amorphous: 37 µm/(m·K) (at 25 °C)
Thermal conductivity	amorphous: 0.519 W/(m·K)
Magnetic ordering	diamagnetic[3]
Young's modulus	10 GPa
Shear modulus	3.7 GPa
Bulk modulus	8.3 GPa
Poisson ratio	0.33
Mohs hardness	2.0
Brinell hardness	736 MPa
CAS Number	7782-49-2
History	
Naming	after Selene, Greek goddess of the moon
Discovery and first isolation	Jöns Jakob Berzelius and Johann Gottlieb Gahn (1817)
Most stable isotopes of selenium	

iso	NA	half-life	DM	DE (MeV)	DP
^{72}Se	syn	8.4 d	ε	–	^{72}As
			γ	0.046	–
^{74}Se	0.86%	is stable with 40 neutrons			
^{75}Se	syn	119.779 d	ε	–	^{75}As
			γ	0.264, 0.136, 0.279	–
^{76}Se	9.23%	is stable with 42 neutrons			
^{77}Se	7.60%	is stable with 43 neutrons			
^{78}Se	23.69%	is stable with 44 neutrons			
^{79}Se	trace	3.27×10^{5} y	β^-	0.151	^{79}Br
^{80}Se	49.80%	is stable with 46 neutrons			
^{82}Se	8.82%	1.08×10^{20} y	$\beta^-\beta^-$	2.995	^{82}Kr