

Manganese

Manganese is a chemical element with the symbol Mn and atomic number 25. It is not found as a free element in nature; it is often found in minerals in combination with iron. Manganese is a transition metal with a multifaceted array of industrial alloy uses, particularly in stainless steels.

Manganese, $_{25}\text{Mn}$



Manganese

Pronunciation */ˈmæŋɡəniːz/* (*MANG-gə-nee-z*)

Appearance silvery metallic

Standard atomic weight $A_{r, \text{std}}(\text{Mn})$ 54.938 043(2)^[1]

Atomic radius

empirical: 127 μm

Covalent radius

Low spin: 139 ± 5 pm

High spin: 161 ± 8 pm



Spectral lines of manganese

Other properties

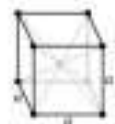
Natural occurrence

primordial

Crystal structure

body-centered cubic

(bcc)



Speed of sound

5150 m/s (at 20 °C)

thin rod

<u>Thermal expansion</u>	21.7 $\mu\text{m}/(\text{m}\cdot\text{K})$ (at 25 °C)
<u>Thermal conductivity</u>	7.81 $\text{W}/(\text{m}\cdot\text{K})$
<u>Electrical resistivity</u>	1.44 $\mu\Omega\cdot\text{m}$ (at 20 °C)
<u>Magnetic ordering</u>	paramagnetic
<u>Magnetic susceptibility</u>	(a) $+529.0\cdot 10^{-6} \text{ cm}^3/\text{mol}$ (293 K) ^[2]
<u>Young's modulus</u>	198 GPa
<u>Bulk modulus</u>	120 GPa
<u>Mohs hardness</u>	6.0
<u>Brinell hardness</u>	196 MPa

History

Discovery

Carl Wilhelm Scheele
(1774)

First isolation

Johann Gottlieb Gahn
(1774)

Main isotopes of manganese

<u>Isotope</u>	<u>Abundance</u>	<u>Half-life ($t_{1/2}$)</u>	<u>Decay mode</u>	<u>Product</u>
⁵² Mn	syn	5.6 d	ϵ	⁵² Cr
			β^+	⁵² Cr
			γ	-
⁵³ Mn	<u>trace</u>	3.74×10 ⁶ y	ϵ	⁵³ Cr
⁵⁴ Mn	syn	312.03 d	ϵ	⁵⁴ Cr
			γ	-
⁵⁵ Mn	100%		<u>stable</u>	

Historically, manganese is named for pyrolusite and other black minerals from the region of Magnesia in Greece, which also gave its name to magnesium and the iron ore magnetite. By the mid-18th century, Swedish- German chemist Carl Wilhelm Scheele had used pyrolusite to produce chlorine. Scheele and others were aware that pyrolusite (now known to be manganese dioxide) contained a new element, but they were unable to isolate it. Johan Gottlieb Gahn was the first to isolate an impure sample of manganese

metal in 1774, which he did by reducing the dioxide with carbon.

Manganese phosphating is used for rust and corrosion prevention on steel. Ionized manganese is used industrially as pigments of various colors, which depend on the oxidation state of the ions. The permanganates of alkali and alkaline earth metals are powerful oxidizers. Manganese dioxide is used as the cathode (electron acceptor) material in zinc-carbon and alkaline batteries.

In biology, manganese(II) ions function as cofactors for a large variety of enzymes with many functions.^[3] Manganese enzymes are particularly essential in detoxification of superoxide free radicals in organisms that must deal with elemental oxygen. Manganese also functions in the oxygen-evolving complex of photosynthetic plants. While the element is a required trace mineral for all known living organisms, it also acts as a neurotoxin in larger amounts. Especially through inhalation, it can cause manganism, a condition in mammals

Manganese in Oceanic Environment

Many trace elements in the ocean come from metal-rich hydrothermal particles from hydrothermal vents.^[4] Dissolved manganese (dMn) is found throughout the world's oceans, 90% of which originates from hydrothermal vents.^[5] Particulate Mn develops in buoyant plumes over an active vent source, while the dMn behaves

conservatively.^[4] Mn concentrations vary between the water columns of the ocean. At the surface, dMn is elevated due to input from external sources such as rivers, dust, and shelf sediments. Coastal sediments normally have lower Mn concentrations, but can increase due to anthropogenic discharges from industries such as mining and steel manufacturing, which enter the ocean from river inputs. Surface dMn concentrations can also be elevated biologically through photosynthesis and physically from coastal upwelling and wind-driven surface

higher when oxygen levels are low. Overall, dMn concentrations are normally higher in coastal regions and decrease when moving offshore.^[6]

Characteristics

Chemical properties



Electrolytically refined manganese chips and a 1 cm³ cube

Manganese is a silvery-gray metal that resembles iron. It is hard and very brittle, difficult to fuse, but easy to oxidize.^[7]

Manganese metal and its common ions are paramagnetic.^[8] Manganese tarnishes slowly in air and oxidizes ("rusts") like iron in water containing dissolved oxygen.

Isotopes

Naturally occurring manganese is composed of one stable isotope, ^{55}Mn .

Several radioisotopes have been isolated and described, ranging in atomic weight

from 44 \underline{u} (^{44}Mn) to 69 u (^{69}Mn). The most stable are ^{53}Mn with a half-life of 3.7 million years, ^{54}Mn with a half-life of 312.2 days, and ^{52}Mn with a half-life of 5.591 days. All of the remaining radioactive isotopes have half-lives of less than three hours, and the majority of less than one minute. The primary decay mode in isotopes lighter than the most abundant stable isotope, ^{55}Mn , is electron capture and the primary mode in heavier isotopes is beta decay.^[9] Manganese also has three meta states.^[9]

examples of low-spin, $S = 1/2$ manganese(II).^[12] There are no spin-allowed d-d transitions in manganese(II), explaining why manganese(II) compounds are typically pale to colorless.^[13]

Oxidation states of manganese^[14]

0	<u>Mn₂(CO)₁₀</u>
+1	<u>MnC₅H₄CH₃(CO)₃</u>
+2	MnCl₂ , MnCO₃ , MnO
+3	<u>MnF₃</u> , <u>Mn(OAc)₃</u> , <u>Mn₂O₃</u>
+4	MnO₂
+5	K₃MnO₄
+6	K₂MnO₄
+7	KMnO₄ , Mn₂O₇
Common oxidation states are in bold.	

The +3 oxidation state is known in compounds like manganese(III) acetate, but these are quite powerful oxidizing

agents and also prone to disproportionation in solution, forming manganese(II) and manganese(IV). Solid compounds of manganese(III) are characterized by its strong purple-red color and a preference for distorted octahedral coordination resulting from the Jahn-Teller effect.

The oxidation state +5 can be produced by dissolving manganese dioxide in molten sodium nitrite.^[15] Manganate (VI) salts can be produced by dissolving Mn compounds, such as manganese dioxide,