Chromium

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Chromium is a chemical element with symbol **Cr** and atomic number 24. It is the first element in Group 6. It is a steely-grey, lustrous, hard and brittle metal[3] which takes a high polish, resists tarnishing, and has a high melting point. The name of the element is derived from the Greek word χρῶμα, *chrōma*, meaning color,[4] because many of the compounds are intensely colored.

Ferrochromium alloy is commercially produced from chromite by silicothermic or aluminothermic reactions; and chromium metal by roasting and leaching processes followed by reduction with carbon and then aluminium. Chromium metal is of high value for its high corrosion resistance and hardness. A major development was the discovery that steel could be made highly resistant to corrosion and discoloration by adding metallic chromium to form stainless steel. Stainless steel and chrome plating (electroplating with chromium) together comprise 85% of the commercial use.

Trivalent chromium (Cr(III)) ion is an essential nutrient in trace amounts in humans for insulin, sugar and lipid metabolism, although the issue is debated.[5]

While chromium metal and Cr(III) ions are not considered toxic, hexavalent chromium (Cr(VI)) is toxic and carcinogenic. Abandoned chromium production sites often require environmental cleanup.

Characteristics

Physical

Chromium is remarkable for its magnetic properties: it is the only elemental solid which shows antiferromagnetic ordering at room temperature (and below). Above 38 °C, it changes to paramagnetic.[2]

Passivation

Chromium, $_{24}$Cr

chromium crystals

General properties	
Name, symbol	chromium, Cr
Appearance	silvery metallic
Chromium in the periodic table	
Atomic number (*Z*)	24
Group, block	group 6, d-block
Period	period 4
Element category	□ transition metal
Standard atomic weight (±) (A_r)	51.9961(6)[1]
Electron configuration	[Ar] $3d^5$ $4s^1$
per shell	2, 8, 13, 1
Physical properties	
Phase	solid
Melting point	2180 K (1907 °C, 3465 °F)
Boiling point	2944 K (2671 °C, 4840 °F)
Density near r.t.	7.19 g/cm^3

Chromium metal left standing in air is passivated by oxidation, forming a thin, protective, surface layer. This layer is a spinel structure only a few molecules thick. It is very dense, and prevents the diffusion of oxygen into the underlying metal. This is different from the oxide that forms on iron and carbon steel, through which elemental oxygen continues to migrate, reaching the underlying material to cause incessant rusting.[6] Passivation can be enhanced by short contact with oxidizing acids like nitric acid. Passivated chromium is stable against acids. Passivation can be removed with a strong reducing agent that destroys the protective oxide layer on the metal. Chromium metal treated in this way readily dissolves in weak acids.[7]

Chromium, unlike such metals as iron and nickel, does not suffer from hydrogen embrittlement. However, it does suffer from nitrogen embrittlement, reacting with nitrogen from air and forming brittle nitrides at the high temperatures necessary to work the metal parts.[8]

Occurrence

Crocoite ($PbCrO_4$)

Chromium is the 22nd most abundant element in Earth's crust with an average concentration of 100 ppm.[9] Chromium compounds are found in the environment from the erosion of chromium-containing rocks, and can be redistributed by volcanic eruptions. Typical background concentrations of chromium in environmental media are: atmosphere <10 ng m^{-3}; soil <500 mg kg^{-1}; vegetation <0.5 mg kg^{-1}; freshwater <10 ug L^{-1}; seawater <1 ug L^{-1}; sediment <80 mg kg^{-1}.[10]

Chromium is mined as chromite ($FeCr_2O_4$) ore.[11] About two-fifths of the chromite ores and concentrates in the world are produced in South Africa, while Kazakhstan, India, Russia, and Turkey are also substantial producers. Untapped chromite deposits are plentiful, but geographically concentrated in Kazakhstan and southern Africa.[12]

when liquid, at m.p.	6.3 g/cm^3
Heat of fusion	21.0 kJ/mol
Heat of vaporization	347 kJ/mol
Molar heat capacity	23.35 J/(mol·K)

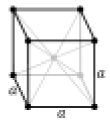
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	1656	1807	1991	2223	2530	2942

Atomic properties

Oxidation states	**6**, 5, 4, **3**, 2, 1, −1, −2, −4 (depending on the oxidation state, an acidic, basic, or amphoteric oxide)
Electronegativity	Pauling scale: 1.66
Ionization energies	1st: 652.9 kJ/mol 2nd: 1590.6 kJ/mol 3rd: 2987 kJ/mol (more)
Atomic radius	empirical: 128 pm
Covalent radius	139±5 pm

Miscellanea

Crystal structure	body-centered cubic (bcc) 
Speed of sound thin rod	5940 m/s (at 20 °C)
Thermal expansion	4.9 µm/(m·K) (at 25 °C)
Thermal conductivity	93.9 W/(m·K)

Electrical resistivity	125 nΩ·m (at 20 °C)
Magnetic ordering	antiferromagnetic (rather: SDW)[2]
Young's modulus	279 GPa
Shear modulus	115 GPa
Bulk modulus	160 GPa
Poisson ratio	0.21
Vickers hardness	1060 MPa
Brinell hardness	687–6500 MPa
CAS Number	7440-47-3
History	
Discovery and first isolation	Louis Nicolas Vauquelin (1797, 1798)

Most stable isotopes of chromium

iso	NA	half-life	DM	DE (MeV)	DP
^{50}Cr	4.345%	is stable with 26 neutrons			
^{51}Cr	syn	27.7025 d	ε	–	^{51}V
			γ	0.320	–
^{52}Cr	83.789%	is stable with 28 neutrons			
^{53}Cr	9.501%	is stable with 29 neutrons			
^{54}Cr	2.365%	is stable with 30 neutrons			


Chromite ore

Although rare, deposits of native chromium exist.[13][14] The Udachnaya Pipe in Russia produces samples of the native metal. This mine is a kimberlite pipe, rich in diamonds, and the reducing environment helped produce both elemental chromium and diamond.[15]

The relation between Cr(III) and Cr(VI) strongly depends on pH and oxidative properties of the location. In most cases, Cr(III) is the dominating species,[16] but in some areas, the ground water can contain up to 39 µg/liter of total chromium of which 30 µg/liter is Cr(VI).[17]

Isotopes

Naturally occurring chromium is composed of three stable isotopes; ^{52}Cr, ^{53}Cr and ^{54}Cr, with ^{52}Cr being the most abundant (83.789% natural abundance). 19 radioisotopes have been characterized, with the most stable being ^{50}Cr with a half-life of (more than) 1.8×10^{17} years, and ^{51}Cr with a half-life of 27.7 days. All of the remaining radioactive isotopes have half-lives that are less than 24 hours and the majority less than 1 minute. This element also has 2 meta states.[18]

^{53}Cr is the radiogenic decay product of ^{53}Mn (half-life = 3.74 million years),[19] and chromium isotopes are typically collocated (and compounded) with manganese isotopes. This circumstance is useful in isotope geology. Mangenese-chromium isotope ratios reinforce the evidence from ^{26}Al and ^{107}Pd concerning the early history of the solar system. Variations in ^{53}Cr/^{52}Cr and Mn/Cr ratios from several meteorites indicate an initial ^{53}Mn/^{55}Mn ratio that suggests Mn-Cr isotopic composition must result from in-situ decay of ^{53}Mn in differentiated planetary bodies. Hence ^{53}Cr provides additional evidence for nucleosynthetic processes immediately before coalescence of the solar system.[20]

The isotopes of chromium range in atomic mass from 43 u (^{43}Cr) to 67 u (^{67}Cr). The primary decay mode before the most abundant stable isotope, ^{52}Cr, is electron capture and the primary mode after is beta decay.[18] ^{53}Cr has been posited as a proxy for atmospheric oxygen concentration.[21]

Source

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