

= Chromium =

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 which takes a high polish , resists tarnishing , and has a high melting point . The name of the element is derived from the Greek word ????? , chr?ma , meaning color , 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 .

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 .

= = = = Passivation = = = =

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 . 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 .

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 .

= = = Occurrence = = =

Chromium is the 22nd most abundant element in Earth 's crust with an average concentration of 100 ppm . 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 .

Chromium is mined as chromite (FeCr₂O₄) ore . 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 .

Although rare, deposits of native chromium exist. 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.

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, 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).

== 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.

^{53}Cr is the radiogenic decay product of ^{53}Mn (half @-@ life = 3 @. 74 million years), and chromium isotopes are typically collocated (and compounded) with manganese isotopes. This circumstance is useful in isotope geology. Manganese @-@ chromium isotope ratios reinforce the evidence from ^{26}Al and ^{107}Pd concerning the early history of the solar system. Variations in $^{53}\text{Cr} / ^{52}\text{Cr}$ and Mn / Cr ratios from several meteorites indicate an initial $^{53}\text{Mn} / ^{55}\text{Mn}$ 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.

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. ^{53}Cr has been posited as a proxy for atmospheric oxygen concentration.

== Compounds ==

Chromium is a member of Group 6, of the transition metals. Chromium (0) has an electronic configuration of $4s^1 3d^5$, owing to the lower energy of the high spin configuration. Chromium exhibits a wide range of oxidation states, with + 3 the most stable; the + 3 and + 6 states are the most common in chromium compounds, while + 1, + 4 and + 5 are rare.

The following is the Pourbaix diagram for chromium in pure water, perchloric acid or sodium hydroxide:

== Chromium (III) ==

A large number of chromium (III) compounds are known. Chromium (III) can be obtained by dissolving elemental chromium in acids like hydrochloric acid or sulfuric acid. The Cr^{3+} ion has a similar radius (63 pm) to Al^{3+} (radius 50 pm), and they can replace each other in some compounds, such as in chrome alum and alum. When a trace amount of Cr^{3+} replaces Al^{3+} in corundum (aluminium oxide, Al_2O_3), pink sapphire or red @-@ colored ruby is formed, depending on the amount of chromium.

Chromium (III) ions tend to form octahedral complexes. The color of these complexes is determined by the ligands attached to the Cr center. Commercially available chromium (III) chloride hydrate is the dark green complex $[\text{CrCl}_2(\text{H}_2\text{O})_4]\text{Cl}$. Closely related compounds have different colors: pale green $[\text{CrCl}(\text{H}_2\text{O})_5]\text{Cl}_2$ and violet $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$. If water @-@ free green chromium (III) chloride is dissolved in water, the green solution turns violet after some time as the chloride in the inner coordination sphere is replaced by water. This kind of reaction is also observed with solutions of chrome alum and other water @-@ soluble chromium (III) salts.

Chromium (III) hydroxide ($\text{Cr}(\text{OH})_3$) is amphoteric, dissolving in acidic solutions to form $[\text{Cr}(\text{OH})_4]^-$.

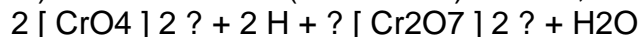
$\text{H}_2\text{O}) 6] 3 +$, and in basic solutions to form $[\text{Cr}(\text{OH})$

$6] 3 ?$. It is dehydrated by heating to form the green chromium (III) oxide (Cr_2O_3), a stable oxide with a crystal structure identical to that of corundum .

== Chromium (VI) ==

Chromium (VI) compounds are powerful oxidants at low or neutral pH . Most important are chromate anion (CrO_4^{2-})

and dichromate ($\text{Cr}_2\text{O}_7^{2-}$) anions , which exist in equilibrium :



Chromium (VI) halides are known also and include the hexafluoride CrF_6 and chromyl chloride (CrO_2Cl_2) .

Sodium chromate is produced industrially by the oxidative roasting of chromite ore with calcium or sodium carbonate . The dominant species is therefore , by the law of mass action , determined by the pH of the solution . The change in equilibrium is visible by a change from yellow (chromate) to orange (dichromate) , such as when an acid is added to a neutral solution of potassium chromate . At yet lower pH values , further condensation to more complex oxoanions of chromium is possible .

Both the chromate and dichromate anions are strong oxidizing reagents at low pH :

CrO_4^{2-}

$\text{Cr}_2\text{O}_7^{2-}$

$7 + 14 \text{H}^+$

$3\text{O}^{2-} + 6 \text{e}^- \rightarrow 2 \text{Cr}^{3+} + 21 \text{H}^+$