

# Cobalt

From Wikipedia, the free encyclopedia

**Cobalt** is a chemical element with symbol **Co** and atomic number 27. Like nickel, cobalt is found in the Earth's crust only in chemically combined form, save for small deposits found in alloys of natural meteoric iron. The free element, produced by reductive smelting, is a hard, lustrous, silver-gray metal.

Cobalt-based blue pigments (cobalt blue) have been used since ancient times for jewelry and paints, and to impart a distinctive blue tint to glass, but the color was later thought by alchemists to be due to the known metal bismuth. Miners had long used the name *kobold ore* (German for *goblin ore*) for some of the blue-pigment producing minerals; they were so named because they were poor in known metals, and gave poisonous arsenic-containing fumes upon smelting. In 1735, such ores were found to be reducible to a new metal (the first discovered since ancient times), and this was ultimately named for the *kobold*.

Today, some cobalt is produced specifically from various metallic-lustered ores, for example cobaltite (CoAsS), but the main source of the element is as a by-product of copper and nickel mining. The copper belt in the Democratic Republic of the Congo, Central African Republic and Zambia yields most of the cobalt mined worldwide.

Cobalt is primarily used in the preparation of magnetic, wear-resistant and high-strength alloys. The compounds, cobalt silicate and cobalt(II) aluminate (CoAl<sub>2</sub>O<sub>4</sub>, cobalt blue) give a distinctive deep blue color to glass, ceramics, inks, paints and varnishes. Cobalt occurs naturally as only one stable isotope, cobalt-59. Cobalt-60 is a commercially important radioisotope, used as a radioactive tracer and for the production of high energy gamma rays.

Cobalt is the active center of coenzymes called cobalamins, the most common example of which is vitamin B<sub>12</sub>. As such, it is an essential trace dietary mineral for all animals. Cobalt in inorganic form is also a micronutrient for bacteria, algae and fungi.

## Cobalt, <sup>27</sup>Co



electrolytically refined cobalt chips

### General properties

<b>Name, symbol</b>	cobalt, Co
<b>Appearance</b>	hard lustrous bluish gray metal

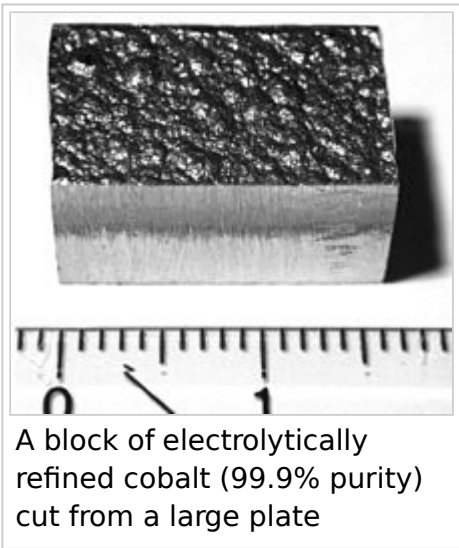
### Cobalt in the periodic table

<b>Atomic number</b> ( <i>Z</i> )	27
<b>Group, block</b>	group 9, d-block
<b>Period</b>	period 4
<b>Element category</b>	<span>▯</span> transition metal
<b>Standard atomic weight</b> ( <i>±</i> ) ( <i>A</i> <sub>r</sub> )	58.933194(4) <sup>[1]</sup>
<b>Electron configuration</b>	[Ar] 3d <sup>7</sup> 4s <sup>2</sup>
<b>per shell</b>	2, 8, 15, 2

### Physical properties

<b>Color</b>	metallic gray
<b>Phase</b>	solid
<b>Melting point</b>	1768 K (1495 °C, 2723 °F)

# Characteristics



A block of electrolytically refined cobalt (99.9% purity) cut from a large plate

Cobalt is a ferromagnetic metal with a specific gravity of 8.9. The Curie temperature is 1,115 °C (2,039 °F)<sup>[3]</sup> and the magnetic moment is 1.6–1.7 Bohr magnetons per atom.<sup>[4]</sup> Cobalt has a relative permeability two-thirds that of iron.<sup>[5]</sup> Metallic cobalt occurs as two crystallographic structures: hcp and fcc. The ideal transition temperature between the hcp and fcc structures is 450 °C (842 °F), but in practice, the energy difference is so small that random intergrowth of the two is common.<sup>[6][7][8]</sup>

Cobalt is a weakly reducing metal that is protected from oxidation by a passivating oxide

film. It is attacked by halogens and sulfur. Heating in oxygen produces Co<sub>3</sub>O<sub>4</sub> which loses oxygen at 900 °C (1,650 °F) to give the monoxide CoO.<sup>[9]</sup> The metal reacts with fluorine (F<sub>2</sub>) at 520 K to give CoF<sub>3</sub>; with chlorine (Cl<sub>2</sub>), bromine (Br<sub>2</sub>) and iodine (I<sub>2</sub>), producing equivalent binary halides. It does not react with hydrogen gas (H<sub>2</sub>) or nitrogen gas (N<sub>2</sub>) even when heated, but it does react with boron, carbon, phosphorus, arsenic and sulfur.<sup>[10]</sup> At ordinary temperatures, it reacts slowly with mineral acids, and very slowly with moist, but not with dry, air.

## Isotopes

<sup>59</sup>Co is the only stable cobalt isotope and the only isotope to exist naturally on Earth. There are 22 radioisotopes that have been characterized, the most stable being <sup>60</sup>Co with a half-life of 5.2714 years, <sup>57</sup>Co with a half-life of 271.8 days, <sup>56</sup>Co with a half-life of 77.27 days, and <sup>58</sup>Co with a half-life of 70.86 days. All of the remaining radioactive isotopes have half-lives that are

<b>Boiling point</b>	3200 K (2927 °C, 5301 °F)
<b>Density</b> near r.t.	8.90 g/cm <sup>3</sup>
when liquid, at m.p.	8.86 g/cm <sup>3</sup>
<b>Heat of fusion</b>	16.06 kJ/mol
<b>Heat of vaporization</b>	377 kJ/mol
<b>Molar heat capacity</b>	24.81 J/(mol·K)

### Vapor pressure

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	1790	1960	2165	2423	2755	3198

### Atomic properties

<b>Oxidation states</b>	−3, −1, +1, <b>+2</b> , <b>+3</b> , +4, +5 <sup>[2]</sup> (an amphoteric oxide)
<b>Electronegativity</b>	Pauling scale: 1.88
<b>Ionization energies</b>	1st: 760.4 kJ/mol 2nd: 1648 kJ/mol 3rd: 3232 kJ/mol (more)
<b>Atomic radius</b>	empirical: 125 pm
<b>Covalent radius</b>	Low spin: 126±3 pm High spin: 150±7 pm

### Miscellanea

<b>Crystal structure</b>	hexagonal close-packed (hcp)
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<b>Speed of sound</b> thin rod	4720 m/s (at 20 °C)
<b>Thermal expansion</b>	13.0 μm/(m·K) (at 25 °C)
<b>Thermal conductivity</b>	100 W/(m·K)

shorter than 18 hours, and the majority of these are shorter than 1 second. This element also has 4 meta states, all of which have half-lives shorter than 15 minutes.<sup>[20]</sup>

The isotopes of cobalt range in atomic weight from 50 u (<sup>50</sup>Co) to 73 u (<sup>73</sup>Co). The primary decay mode for isotopes with atomic mass unit values less than that of the most abundant stable isotope, <sup>59</sup>Co, is electron capture and the primary mode of decay for those of greater than 59 atomic mass units is beta decay. The primary decay products before <sup>59</sup>Co are element 26 (iron) isotopes and the primary products after are element 28 (nickel) isotopes.<sup>[20]</sup>

## Source

- Wikipedia: Cobalt (<https://en.wikipedia.org/wiki/Cobalt>)

Electrical resistivity

62.4 nΩ·m (at 20 °C)

Magnetic ordering

ferromagnetic

Young's modulus

209 GPa

Shear modulus

75 GPa

Bulk modulus

180 GPa

Poisson ratio

0.31

Mohs hardness

5.0

Vickers hardness

1043 MPa

Brinell hardness

470–3000 MPa

CAS Number

7440-48-4

History

Discovery

Georg Brandt (1732)

Most stable isotopes of cobalt

iso	NA	half-life	DM	DE (MeV)	DP
<sup>56</sup> Co	syn	77.27 d	ε	4.566	<sup>56</sup> Fe
<sup>57</sup> Co	syn	271.79 d	ε	0.836	<sup>57</sup> Fe
<sup>58</sup> Co	syn	70.86 d	ε	2.307	<sup>58</sup> Fe
<sup>59</sup> Co	100%	is stable with 32 neutrons			
<sup>60</sup> Co	syn	5.2714 y	β <sup>−</sup> , γ	2.824	<sup>60</sup> Ni