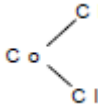
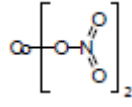


CHAPTER 4. CHEMICAL AND PHYSICAL INFORMATION

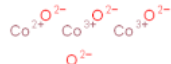
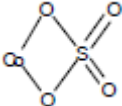
4.1. CHEMICAL IDENTITY

Cobalt is a naturally occurring element in the earth's crust. It occurs in several minerals, often with nickel, silver, lead, copper, and iron ores (Haynes 2015). It is a member of Group 9 of the periodic table along with rhenium, iridium, and meitnerium, and adjacent to iron and nickel. There is only one stable isotope of cobalt, ^{59}Co . The rest of the 31 known isotopes of cobalt are not naturally occurring. Most of the radioactive forms have masses from 47-58 and 60-77. The radioactive properties of these are maintained in the US by the National Nuclear Data Center. ^{60}Co , the most common radioisotope, is formed by the neutron activation of stable ^{59}Co , has a 5.27 year half-life, and emits beta particles (99.77 keV 99.88%) and gamma radiation (1173 keV 99.85%, 1332 keV 99.98%) (NNDC 2021). It is used as a source of high energy gamma radiation in cancer therapy (e.g., in a gamma knife), food irradiation, and industrial radiography of welds. It along with primarily ^{57}Co and ^{58}Co are waste byproducts of nuclear reactor operations. Cobalt isotopes have half-lives that are specific to the isotope, and most are less than 24 hours (NNDC 2021). The isotopes of cobalt have the same chemical and physical properties, so they interact the same with biological systems. Table 4-1 lists common synonyms, trade names, and other pertinent identification information for cobalt and selected cobalt compounds.

Table 4-1. Chemical Identity of Cobalt and Selected Cobalt Compounds

Characteristic	Cobalt	Cobalt(II) Chloride	Cobalt(II) Nitrate
Synonym(s) and Registered trade name(s)	CI 77320; Kobalt; NCI-C60311; Aquacat; Cobalt-59; Super Cobalt	Cobaltous chloride; Cobalt dichloride; Cobalt muriate; Cobaltous dichloride; Kobalt chloride	Cobaltous nitrate; Cobalt bis(nitrate); Cobalt dinitrate; Cobalt (2+) nitrate; cobalt nitrate
Chemical formula	Co	CoCl_2	$\text{Co}(\text{NO}_3)_2$
Chemical structure	Co		
CAS registry number	7440-48-4	7646-79-9 (anhydrous)	10141-05-6 (anhydrous)

4. CHEMICAL AND PHYSICAL INFORMATION

Characteristic	Cobalt(II) Oxide	Cobalt Tetraoxide	Cobalt(II) Sulfate
Synonym(s) and Registered trade name(s)	Cobalt monoxide; Cobalt Black; Zaffre; Oxocobalt; Cobaltous Oxide; Monocobalt oxide; CI Pigment Black 13	Cobalt oxide; UNII-USK772NS56; Cobaltosic oxide; Cobalt oxide black; Tricobalt tetroxide; Cobalto-cobaltic oxide; Cobaltic-cobaltous oxide; Cobalto-cobaltic tetroxide; Cobalt(II, III) oxide	Cobaltous sulfate; Cobalt(II) sulphate; Cobalt(II) sulfate (1:1); Cobalt(2+) sulfate; Cobalt sulfate; Sulfuric acid, cobalt(2+) salt (1:1)
Chemical formula	CoO	Co ₃ O ₄	CoSO ₄
Chemical structure	O=Co		
CAS registry number	1307-96-6	1308-06-1	10124-43-3 (anhydrous)
Characteristic	Cobalt(II) Sulfide	Cobalt Arsenide	
Synonym(s) and Registered trade name(s)	Cobalt sulfide; sulfanylidencobalt; cobalt sulphide; cobalto monosulfide; cobalt (2+) sulfide; cobaltous sulfide	Arsanylidynecobalt; cobalt monoarsenide; cobalt(III) arsenide	
Chemical formula	CoS	CoAs	
Chemical structure	S=Co	Co≡As	
CAS registry number	1317-42-6	27016-73-5	

CAS = Chemical Abstracts Service

Source: (HSDB 2017a, 2017b, 2017c, 2017d); (PubChem 2021a, 2021b, 2021c, 2021d, 2021e)

4.2. PHYSICAL AND CHEMICAL PROPERTIES

Cobalt is a magnetic, brittle, hard, gray metal that is resistant to oxidation (Haynes 2015). Cobalt's physical and chemical properties make it ideal for a variety of applications. Alloys containing cobalt can maintain their strength at high temperatures, making them useful in gas turbine engines, chemical and petroleum plants, and power plants (USGS 2011). Cobalt and cobalt compounds are nonvolatile and are emitted to the atmosphere in particulate form. Soluble chloride released to waterways is expected to sorb to particles. Cobalt is also an essential trace element found in Vitamin B₁₂.

Table 4-2 lists important physical and chemical properties of cobalt and cobalt compounds.

4. CHEMICAL AND PHYSICAL INFORMATION

Table 4-2. Physical and Chemical Properties of Cobalt and Selected Cobalt Compounds

Property	Cobalt	Cobalt(II) Chloride	Cobalt(II) Nitrate
Molecular weight	58.933 ^a	129.8 ^a	182.9 ^a
Color	Gray, silvery bluish-white ^{a,b}	Blue ^a	Pale red ^a
Physical state	Solid ^c	Solid	Solid ^g
Melting point	1,495°C ^a	737 °C ^a	Decomposes at 100-105 °C ^g
Boiling point	2,927°C ^a	1049 °C ^a	No data
Density at 20°C/4°C	8.9 g/cm ^{3a}	3.36 g/cm ^{3a}	2.49 g/cm ^{3a}
Odor	Odorless ^c	Slight sharp odor ^f	Odorless ^g
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Taste threshold	No data	No data	No data
Solubility:			
Water	No data	Soluble in water ^f	Soluble in water ^g
Organic solvent(s)	Soluble in dilute acids; readily soluble in dilute nitric acid ^{a,d}	Soluble in alcohols, acetone, ether, glycerol, and pyridine ^f	No data
Partition coefficients:			
Log K _{ow}	No data	No data	No data
Log K _{oc}	No data	No data	No data
Vapor pressure:			
At 726 mmHg and 85°C	2.09×10 ⁻¹⁰ mmHg ^a	No data	No data
Approximately	0 mmHg ^c	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	1 ppm = 2.4 mg/m ^{3e}	No data	No data
Explosive limits	No data	Reacts violently with alkali metals such as potassium or sodium causing fire and explosion hazard ^f	No data

4. CHEMICAL AND PHYSICAL INFORMATION

Table 4-2. Physical and Chemical Properties of Cobalt and Selected Cobalt Compounds

Property	Cobalt(II) Oxide	Cobalt Tetraoxide	Cobalt(II) Sulfate
Molecular weight	74.932 ^a	240.8 ^a	155 ^a
Color	Gray ^a	Black ^a	Red ^a
Physical state	Solid ^a	Solid ^a	Solid ^h
Melting point	1,830°C ^a	Decomposes at 900°C ^a	>700 °C ^a
Boiling point	No data	No data	No data
Density at 20°C/4°C	4.63 g/cm ^{3a}	6.11 g/cm ^{3a}	3.71 g/cm ^{3a}
Odor	No data	No data	Odorless ⁱ
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Taste threshold	No data	No data	No data
Solubility:			
Water	Insoluble in water ^a	Insoluble in water ^a	330 g/L at 20 °C ^h
Organic solvent(s)	Soluble in acid solutions ^a	Soluble in acid solutions and alkaline solutions ^a	1.04 g/11 mL methanol at 18 °C ^h
Partition coefficients:			
Log K _{OW}	No data	No data	No data
Log K _{OC}	No data	No data	No data
Vapor pressure	No data	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

4. CHEMICAL AND PHYSICAL INFORMATION

Table 4-2. Physical and Chemical Properties of Cobalt and Selected Cobalt Compounds

Property	Cobalt(II) Sulfide	Cobalt Arsenide
Molecular weight	90.998 ^a	133.855 ^a
Color	Black ^a	No data
Physical state	Solid ^a	Solid ^a
Melting point	1,117°C ^a	1,180°C ^a
Boiling point	No data	No data
Density at 20°C/4°C	5.45 g/cm ^{3a}	8.22 g/cm ^{3a}
Odor	No data	No data
Odor threshold:		
Water	No data	No data
Air	No data	No data
Taste threshold	No data	No data
Solubility:		
Water	Insoluble in water ^a	No data
Organic solvent(s)	Soluble in acid solutions ^a	No data
Partition coefficients:		
Log K _{ow}	No data	No data
Log K _{oc}	No data	No data
Vapor pressure	No data	No data
Henry's law constant	No data	No data
Autoignition temperature	No data	No data
Flashpoint	No data	No data
Flammability limits	No data	No data
Conversion factors	No data	No data
Explosive limits	No data	No data

^a (Haynes 2015)^b Browning 1996^c (NIOSH 2019)^d O'Neil 2013^e (EPA 2000)^f (HSDB 2017c)^g (HSDB 2017d)^h (HSDB 2017a)ⁱ (PubChem 2021d)