

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

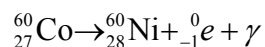
4.1 CHEMICAL IDENTITY

Cobalt is a naturally-occurring element that appears in the first transition series of Group 9 (VIII) of the periodic table along with iron and nickel. There is only one stable isotope of cobalt, ^{59}Co . There are about 26 known radioactive isotopes of cobalt, of which only two are of commercial importance, ^{60}Co and ^{57}Co . ^{60}Co , a commonly-used source of gamma radiation, is the most important radionuclide. It may be a low-level contaminant of cooling water released by nuclear reactors. Table 4-1 summarizes information on the chemical identity of elemental cobalt and some common cobalt compounds.

4.2 PHYSICAL, CHEMICAL, AND RADIOLOGICAL PROPERTIES

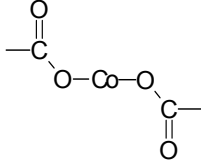
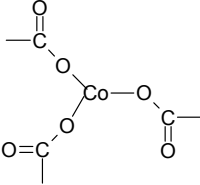
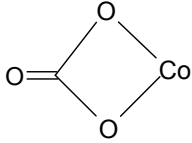
Cobalt commonly occurs in the 0, +2, and +3 valence states. Compounds containing cobalt in the -1, +1, +4, and +5 oxidation state are few and uncommon (Cotton and Wilkinson 1980). Cobalt (II) is much more stable than Co(III), and Co^{3+} is a sufficiently powerful oxidizing agent to oxidize water, liberating oxygen. Table 4-2 summarizes important physical and chemical properties of elemental cobalt and some common cobalt compounds. These properties are similar to those of its neighbors in Group 9 of the periodic table, iron and nickel. Metallic cobalt, Co(0), occurs as two allotropic forms, hexagonal and cubic; the hexagonal form is stable at room temperature. A biochemically important cobalt compound is vitamin B₁₂, or cyanocobalamin, in which cobalt is complexed with four pyrrole nuclei joined in a ring called the corrinoid ligand system (similar to porphyrin).

The Chemical Abstract Service (CAS) registry numbers, decay modes, half-lives, and specific activity of the three principal radioactive cobalt isotopes, ^{57}Co , ^{58}Co , and ^{60}Co , are presented in Table 4-3. ^{60}Co (half-life of 5.27 years) decays by beta decay to nickel-60, a stable isotope (ICRP 1983; Lide 1998).



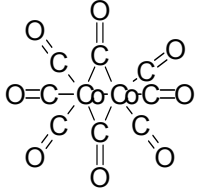
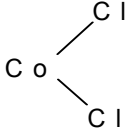

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Characteristic	Cobalt	Cobalt(II) acetate	Cobalt(III) acetate	Cobalt(II) carbonate
Synonym(s)	Cobalt-59, cobalt metal	Cobaltous acetate, cobalt diacetate	Cobaltic acetate, cobalt triacetate	Cobaltous carbonate; carbonic acid; cobalt (+2) salt
Registered trade name(s)	No data	No data	No data	No data
Chemical formula	Co	Co(C ₂ H ₄ O ₂) ₂	Co(C ₂ H ₄ O ₂) ₃	CoCO ₃
Chemical structure	Co			
Identification numbers:				
CAS registry	7440-48-4	71-48-7	917-69-1	513-79-10
NIOSH RTECS	GF8750000	AG3150000	No data	FF9450050
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMCO shipping ^a	UN1318	No data	No data	No data
HSDB	519	997	No data	No data
NCI	C60311	No data	No data	No data

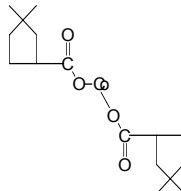
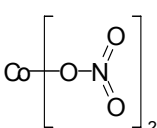
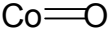
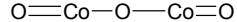
4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Characteristic	Cobalt carbonyl	Cobalt(II) chloride	Cobalt(II) hydroxide	Cobalt(II) meso-porphyrin
Synonym(s)	Dicobalt octa-carbonyl; cobalt tetracarbonyl	Cobalt dichloride; cobaltous chloride	Cobaltous hydr-oxide; cobalt dihydroxide	Cobalt meso-porphyrin IX Cobalt-iprotoporphyrin
Registered trade name(s)	No data	No data	No data	No data
Chemical formula	$\text{Co}_2(\text{CO})_8$	CoCl_2	$\text{Co}(\text{OH})_2$	$\text{C}_{34}\text{H}_{34}\text{CoN}_4\text{O}_4$
Chemical structure				No data
Identification numbers:				
CAS registry	10210-68-1	7646-79-9	21041-93-0	21158-51-0
NIOSH RTECS	GG0300000	GF9800000	No data	No data
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	7217328	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	6345	1000	No data	No data
NCI	No data	No data	No data	No data

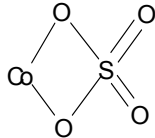
4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Characteristic	Cobalt(II) naphthenate	Cobalt(II) nitrate	Cobalt(II) oxide	Cobalt(III) oxide
Synonym(s)	Naftolite; naphthenic acid, cobalt salt	Cobaltous nitrate	Black 13; C.I. 77322; cobalt monoxide; cobaltous oxide	Cobalt black; cobaltic oxide; cobalt sesquioxide; cobalt trioxide; C.I. 77323
Registered trade name(s)	No data	No data	C.I. Pigment Black 13; Zaffre	No data
Chemical formula	$\text{Co}(\text{C}_{11}\text{H}_{10}\text{O}_2)_2$	$\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	CoO	Co_2O_3
Chemical structure				
Identification numbers:				
CAS registry	10210-68-1	7646-79-9	21041-93-0	21158-51-0
NIOSH RTECS	GG0300000	GF9800000	No data	No data
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	7217328	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	6345	1000	No data	No data
NCI	No data	No data	No data	No data

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Characteristic	Cobalt(II, III) oxide	Cobalt(II) sulfate
Synonym(s)	Cobaltic-cobaltous oxide; cobalt tetra-oxide, tricobalt tetraoxide, cobaltosic oxide; cobalt black; C.I. Pigment Black 13	Cobalt sulfate; cobaltous sulfate
Registered trade name(s)	No data	No data
Chemical formula	Co ₃ O ₄	CoSO ₄
Chemical structure	Co=OO=Co-O-Co=O	
Identification numbers:		
CAS registry	1308-06-1	10124-43-3
NIOSH RTECS	No data	GG3100000
EPA hazardous waste	No data	No data
OHM/TADS	No data	7217330
DOT/UN/NA/IMCO shipping	No data	No data
HSDB	No data	240
NCI	No data	No data

^aThe identification number for radioactive materials is UN2910

CAS = Chemical Abstract Service; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

Source: Budavari 1996; HSDB 2001; RTECS 1987

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Property	Cobalt	Cobalt(II) acetate	Cobalt(III) acetate	Cobalt(II) carbonate
Molecular weight	58.93	177.03	236.07	118.94
Color	Silvery gray	Light pink	Dark green	Red
Physical state	Solid	Solid	Solid	Solid
Melting point, °C	1,495	No data	Decomposes at 100 °C	Decomposes
Boiling point, °C	2,870	No data	Not relevant	Not relevant
Density, g/cm ³	8.9 (20 °C)	No data	No data	4.13
Odor	No data	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water	Insoluble	Soluble	Soluble	0.18 g/100 g H ₂ O at 15 °C
Organic solvent(s)	Insoluble	2.1 g/100 g methanol at 15 °C	soluble in alcohol, acetic acid	Insoluble in ethanol
Partition coefficients:				
Log K _{ow}	No data	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure	1 mmHg at 1,910 °C	No data	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	760 °C for dust cloud	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	Not relevant ^a	Not relevant ^a	Not relevant ^a	Not relevant ^a
Explosive limits	No data	No data	No data	No data

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Property	Cobalt carbonyl	Cobalt(II) chloride	Cobalt(II) hydroxide	Cobalt(II) mesoporphyrin
Molecular weight	341.9	129.84	92.95	621.2 ^b
Color	Orange (white when pure)	Blue	Rose red or blue green	No data
Physical state	Solid	Solid	Solid	No data
Melting point, °C	51	724	No data	No data
Boiling point, °C	Decomposes	1,049	No data	No data
Density, g/cm ³	1.73 at 18 °C	3.356 (36 °C)	3.597 at 15 °C	No data
Odor	No data	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water	Insoluble	450 g/L at 7 °C	0.0032 g/L	No data
Organic solvent(s)	Soluble in ether; insoluble in naphtha	544 g/L in ethanol; 86 g/L in acetone	No data	No data
Partition coefficients:				
Log K _{ow}	No data	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure	199.5 at 25 °C	No data	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature, °C	No data	No data	No data	No data
Flashpoint, °C	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	Not relevant ^a	Not relevant ^a	Not relevant ^a	Not relevant ^a
Explosive limits	No data	No data	No data	No data

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Property	Cobalt(II) naphthenate	Cobalt(II) nitrate	Cobalt(II) oxide	Cobalt(III) oxide
Molecular weight	407	182.94	74.93	165.86
Color	No data	Red	Pink	Black-gray
Physical state	Solid	Solid	Solid	Solid
Melting point, °C	140	Decomposes at 100– 105 ^b	1,795	895 (decomposes)
Boiling point, °C	No data	Not relevant	No data	Not relevant
Density g/cm ³	0.9	2.49 ^b	6.45	5.18
Odor	No data	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water	Insoluble	133.8 at 0 °C ^c	Insoluble	Insoluble
Organic solvent(s)	No data	Soluble in ethanol, acetone	Insoluble in alcohol	Insoluble in ethanol
Partition coefficients:				
Log K _{ow}	No data	No data	No data	No data
Log K _{ow}	No data	No data	No data	No data
Vapor pressure	No data	No data	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	Not relevant ^a	Not relevant ^a	Not relevant ^a	Not relevant ^a
Explosive limits	No data	No data	No data	No data

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

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

Property	Cobalt(II, III) oxide	Cobalt(II) sulfate
Molecular weight	250.80	154.99
Color	Black	Dark blue
Physical state	Solid	Solid
Melting point, °C	-O ₂ at 900–950	Decomposes at 735 °C
Boiling point, °C	Not relevant	Not relevant
Density g/cm ³	6.07	3.71
Odor	No data	No data
Odor threshold:		
Water	No data	No data
Air	No data	No data
Solubility:		
Water	Insoluble	3.83 g/100 mL H ₂ O at 25 °C
Organic solvent(s)	No data	1.04 g/100 mL methanol at 18 °C
Partition coefficients:		
Log K _{ow}	No data	No data
Log K _{ow}	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	Not relevant ^a	Not relevant ^a
Explosive limits	No data	No data

^aSubstances exist in the atmosphere in the particulate state, and the concentration is expressed in weight per cubic meter

^bCAS Online

^cHexahydrate

Source: Budavari 1996; HSDB 2001, 2004; Lide 1994; Stockinger 1981; Weast 1985

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

Table 4-3. Principal Radioactive Cobalt Isotopes

Isotope	CAS registry no.	Decay mode (product)	Decay mode energy (MeV)	Beta radiation		Gamma radiation		Half-life
				Energy (MeV)	Intensity (percent)	Energy (MeV)	Intensity (percent)	
⁵⁵ Co	13982-25-7	E.C. β ⁺ (⁵⁵ Fe)	3.452	1.498	46	0.9312	75	17.53 hours
				1.021	25.6	0.4772	20	
				2.043	10.7	1.408	16.88	
⁵⁷ Co	13981-50-5	E.C. (⁵⁷ Fe)	0.836	0.700	99.8	0.1221	85.6	271.8 days
						0.1365	10.7	
						0.014	9.2	
⁵⁸ Co	13981-38-9	E.C. β ⁺ (⁵⁸ Fe)	2.30	1.4966	83.9	0.811	99	70.86 days
				0.4746	14.9			
⁶⁰ Co	10198-40-0	β ⁻ (⁶⁰ Ni)	2.824	0.3181	99.9	1.173	100	5.271 years
						1.332	100	

B⁻ = negative beta emission; β⁺ = positron emission; E.C. = orbital electron capture

Source: ICRP 1983; LBNL 2000; Lide 1998

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

The decay is accompanied by the emission of 1.173 and 1.332 MeV gamma rays. ^{57}Co (half-life of 271.8 days) and ^{58}Co (half-life of 70.9 days) decay by electron capture and electron capture/positron (β^+) emission to ^{57}Fe and ^{58}Fe , respectively. These decay processes are also accompanied by gamma emissions (Table 4-3).

