

4. CHEMICAL, PHYSICAL, AND RADIOLOGICAL INFORMATION

4.1 CHEMICAL IDENTITY

Iodine is a nonmetallic element belonging to the halogen family in Group VIIA of the periodic table. Iodine is found in nature as iodide (i.e., I⁻) in brines or in molecular compounds with other elements (e.g., iodate or IO₃⁻). The chemical information for elemental iodine and some of its compounds is listed in Table 4-1. Radioactive isotopes of iodine (e.g., see Section 4.2) are an additional cause of concern with regard to human health (see Chapter 3).

4.2 PHYSICAL, CHEMICAL, AND RADIOLOGICAL PROPERTIES

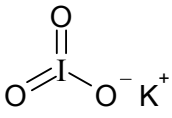
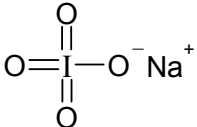
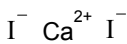

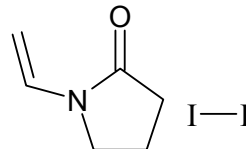
The physical properties of iodine and selected iodine compounds are listed in Table 4-2. The percent occurrence of iodine isotopes and radiological properties of iodine isotopes is listed in Table 4-3.

Iodine can exist in several oxidation states: -1, 0, +1, +3, +5, and +7. Under normal environmental conditions, the -1, 0, and +5 oxidation states are the most important. There are 36 isotopes of iodine having masses between 108 and 143 (Chu et al. 1999); 14 of these yield significant radiation. The only naturally-occurring isotopes of iodine are ¹²⁷I and ¹²⁹I, which are stable and radioactive, respectively. Isotopes of mass less than 127 are produced in particle accelerators (common examples are ¹²³I and ¹²⁵I), while those >127 are formed in neutron generators such as nuclear reactors and atomic bombs (common examples are ¹²⁹I and ¹³¹I). A total of 72% of uranium fissions and 75% of plutonium fissions leads directly or by beta decay of precursors, to iodine isotopes. For example, 2.89% of ²³⁵U and 3.86% of ²³⁹Pu fission atoms lead to the formation of a series of isobar 131 isotopes, including ¹³¹In, ¹³¹Sn, ¹³¹Sb, ¹³¹Te, ¹³¹I, and ¹³¹Xe. Each isotope can be formed as an initial fission product and, once formed, each isotope decays by beta-ray emission to the right on the sequence, through ¹³¹I, and with stable ¹³¹Xe. The process can be displayed as:



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Table 4-1. Chemical Identity of Iodine and Iodine Compounds

Property	Potassium iodate	Sodium periodate	Calcium iodide	Copper (I) iodide	Povidone iodine
Chemical formula	KIO ₃	NaIO ₄	CaI ₂	CuI	C ₆ H ₉ I ₂ NO
Chemical structure					
Synonyms	Iodic acid, potassium salt	Sodium metaperiodate	Calcium diiodide; calcium iodide hydrate	Copper monoiodide; natural marshite; cuprous iodide	Poly(1-(2-oxo-1-pyrrolidinyl)-ethylene)iodine complex; betadine; efodine; Iodopoly(vinyl pyrrolidinone); isobetadyne; isodine; poly(vinylpyrrolidinone) iodide; ultradine
Trade names	None	None	None	None	None
Identification numbers					
CAS registry	7758-05-6	7790-28-5	10102-68-8	7681-65-4	25655-41-8
NIOSH	NN1350000	None	None	None	TR1579600
RTECS					
EPA hazardous waste	None	None	None	None	None
OHM/TADS	None	None	None	None	None
DOT/UN/NA/IMO shipping					
HSDB	1231	None	None	271	6831
NCI		None	None	None	26245
STCC	None	None	None	None	None

CAS = Chemical Abstracts Services; 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; STCC = Standard Transportation Commercial Code

Source: HSDB 2001; Lide 2000

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Table 4-2. Physical and Chemical Properties of Iodine and Iodine Compounds^a

Property	Iodine	Hydrogen iodide	Sodium iodide	Potassium iodide
Molecular weight, g/mole	253.809 ^a	127.91 ^a	149.89 ^a	166.02 ^a
Color	Bluish-black ^a	Colorless ^a	White	Colorless or white ^a
Physical state	Solid; scales or plates ^a	Gas ^a	Solid; crystals or granules	Solid; crystals, granules, or powder ^a
Melting point	113.60 EC ^a	-50.8 EC ^a	651 EC ^a	680 EC ^a
Boiling point	185.24 EC ^a	-35.1 EC ^a	1,304 EC ^d	1,323 EC ^d
Density, g/cm ³ (25 EC)	4.93 ^a	5.23 ^a	3.67 ^a	3.12 ^a
Odor	Characteristic ^a	No data	Odorless ^a	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility (25 EC):				
Water	330 mg/L ^a	2,340 g/L (10 EC) ^a	2,000 g/L ^a	1,429 g/L ^a
Organic solvents(s)	141 g/kg benzene ^a	Soluble ^a	500 g/L alcohol ^a	13 g/L acetone ^a
Partition coefficients:				
Log K _{ow}	2.49 ^b	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure (25 EC)	0.305 mm Hg ^a	5,940 mm Hg ^c	1 mm Hg (767 EC) ^c	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	Non-flammable	No data	No data
Explosive limits	No data	No data	No data	No data

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Table 4-2. Physical and Chemical Properties of Iodine and Iodine Compounds^a

Property	Methyl iodide	Cesium iodide	Potassium iodate	Sodium periodate
Molecular weight, g/mole	141.94 ^a	259.81 ^a	214.02 ^a	213.892 ^d
Color	Colorless ^a	Colorless ^d	White ^a	White ^d
Physical state	Liquid ^a	Solid; crystals, or powder ^a	Solid, crystals ^a	Solid; crystals ^d
Melting point	-66.5 EC ^a	621 EC ^a	560 EC ^a	Decomposes ~300 EC
Boiling point	42.5 EC ^a	ca. 1,280 EC ^a	No data	No data
Density, g/cm ³ (25 EC)	2.28 (20 EC) ^a	4.5 ^a	3.98 ^c	3.86 ^d
Odor	Pungent, ether-like ^c	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 (25 EC):				
Water	13.9 g/L (20 EC) ^c	Miscible ^a	9.16 g/100 g ^c	Soluble ^d
Organic solvents(s)	Miscible ^a	Soluble in alcohol; insoluble in acetone ^a	No data	No data
Partition coefficients:				
Log K _{ow}	1.51 ^c	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure (25 EC)	405 mm Hg	No data	No data	No data
Henry's Law constant	0.00526 atm-cu m/mole	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
Explosive limits	No data	No data	No data	No data

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Table 4-2. Physical and Chemical Properties of Iodine and Iodine Compounds^a

Property	Calcium iodide	Copper (I) iodide	Povidone iodine
Molecular weight, g/mole	293.89 ^a	190.45 ^a	364.95 ^c
Color	Yellow ^a	Red-brown ^a	Yellow-brown ^c
Physical state	Solid; lumps or powder ^a	Solid; powder or crystals ^a	Solid; powder ^c
Melting point	740 EC	588–606 EC ^a	300 EC ^e
Boiling point	1,100 EC	~1,290 EC ^a	No data
Density, g/cm ³ (25 EC)		5.63 ^a	
Odor	No data	No data	Slight characteristic ^c
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility (25 EC)			
Water	Very soluble ^a	80 mg/L (18 EC) ^c	Soluble ^c
Organic solvents(s)	Very soluble in alcohol, acetone ^a	Insoluble ^a	Insoluble ^c
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
Explosive limits	No data	No data	No data

^aBudavari et al. 1998^bHansch and Leo 1995^cHSDB 2000^dLide 2000

Source: Chemfinder 2001, unless otherwise specified

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Table 4-3. Percent Natural Occurrence and Radioactive Properties of Isotopes of Iodine

Isotope	CAS registry number	Natural abundance (%)	Beta energies, MeV ^a (intensity)	Gamma energies, keV ^a	Half-life	Activity, Ci/gram ^c
¹²³ I	15715-08-9	No data	1.08 (97.0%)	158.97	13.3 hours	1.92x10 ⁶
¹²⁴ I	14158-30-6	No data	EC ^b	602.7 722.8 1691.0	4.18 days	2.52x10 ⁵
¹²⁵ I	14158-31-7	No data	EC ^b	35.5	59.4 days	1.76x10 ⁴
¹²⁶ I	14158-32-8	No data	EC ^b	388.6 666.3 753.8	13.11 days	7.91x10 ⁴
¹²⁷ I	7553-56-2	<100	No data	No data	Stable	No data
¹²⁹ I	15046-84-1	1x10 ⁻¹³ to 1x10 ⁻¹⁰	0.154	29.5 29.8 33.6	1.57x10 ⁷ years	1.77x10 ⁴
¹³¹ I	10043-66-0	No data	0.334 (7.3%) 0.606 (89.9%)	284.3 364.5	8.04 days ^d	1.24x10 ⁵
¹³² I	14683-16-0	No data	0.74 (13.0%) 0.96 (8.2%) 1.18 (18.8%) 1.61 (12.6%) 2.14 (19.0%)	667.7 772.6 954.6	2.30 hours	1.03x10 ⁷
¹³³ I	14834-67-4	No data	0.54 (87.0%) 0.88 (4.5%)	529.9 875.3	20.8 hours	1.13x10 ⁶
¹³⁴ I	14914-27-3	No data	1.31 (30.4%) 1.59 (16.2%) 1.82 (11.0%) 2.44 (12.5%)	847.0 884.1	52.5 minutes	2.67x10 ⁷
¹³⁵ I	14834-68-5	No data	679.7 (8.0%) 856.8 (8.8%) 969.9 (21.9%) 1,082.7 (8.0%) 1,387.6 (23.8%)	546.6 836.8 1,038.8 1,131.5	6.57 hours	3.53x10 ⁶

^aNot all gamma and beta energies are included in summary; see Chu et al. (1999) for a complete listing

^bEC = electron capture decay

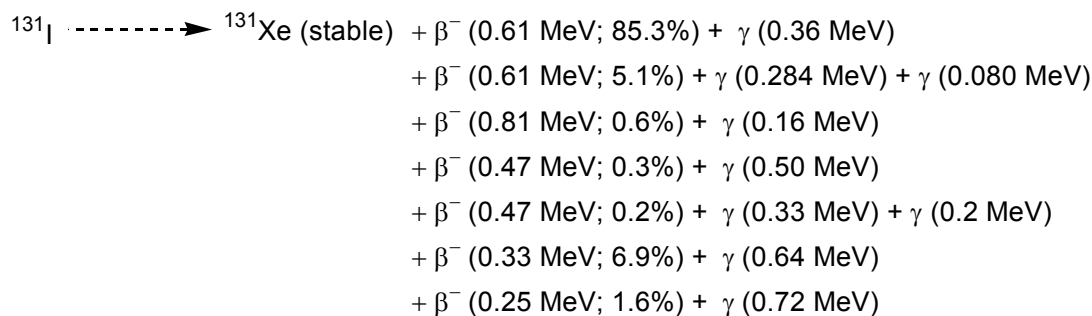
^cActivity = (N_A ln2)/(M_w t_{1/2})

^dLide 2000

Source: Chu et al. 1999

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The same process occurs for ^{129}I ($t_{1/2}=1.6 \times 10^7$ years) and includes mass 129 isobars beginning with ^{129}Cd and ending with ^{129}Xe . Iodine isotopes above ^{127}I decay by emitting beta and gamma radiation, whose combined energies are unique to each iodine isotope. ^{131}I , for example, decays by beta particle emission, and 0.96 MeV of energy is shared between the beta particle and the gamma ray. At least seven possible beta/gamma combinations occur. In 90.4% of the decays, a 0.61 MeV beta particle is emitted. The remaining excess energy is emitted as either a 0.364 MeV gamma ray for 85.3% of the time, or a pair of 0.284 and 0.080 MeV gamma rays for the other 5.1% of the time. The following is the decay scheme for ^{131}I (Cember 1996):



Isotopic masses of iodine <127 can be produced using a beam of high energy protons generated using a linear accelerator. Proton beams tuned at fixed energies up to 30 MeV produce isotopes, such as ^{123}I , by interaction of the proton beam with a target of high atomic mass.