Polonium

What Is It? Polonium is a radioactive element that occurs naturally in very low concentrations in the earth's crust (at about one part in 10^{15}, or one millionth of a trillionth). Polonium was the first element discovered by Marie and Pierre Curie in 1898, while seeking the cause of radioactivity of pitchblende ore containing uranium. Polonium in its pure form is a low-melting, fairly volatile metal. Over 25 isotopes of polonium are known, with atomic masses ranging from 192 to 218 (isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) All polonium isotopes are radioactive, with only three having appreciable half-lives: polonium-208, polonium-209, and polonium-210.

Symbol: **Po**

Atomic Number: **84**
(protons in nucleus)

Atomic Weight: **210**
(naturally occurring)

Polonium-210, historically called "radium F," is the predominant naturally occurring isotope of polonium and the one most widely used. Polonium-210 is a radioactive decay product in the natural uranium-238 decay series; along with lead-210 it is one of two relatively long-lived decay products of radon-222. Polonium-210 has a half-life of 138 days, and it decays to stable lead-206 by emitting an alpha particle. One-thousandth of a gram (1 mg) of polonium-210 emits as many alpha particles as 5 g of radium-226. The energy released by its decay is so large (140 watts/g) that a capsule containing about half a gram reaches a temperature above 500ºC.

Radioactive Properties of Key Polonium Isotopes

Isotope	Half-Life	Specific Activity *(Ci/g)*	Decay Mode	Radiation Energy *(MeV)*		
				Alpha *(α)*	Beta *(β)*	Gamma *(γ)*
Po-208	2.9 yr	590	α	5.1	<	<
Po-209	100 yr	17	α	4.9	<	<
Po-210	140 days	4,500	α	5.3	<	<

Ci = curie, g = gram, and MeV = million electron volts; a "<" means the radiation energy is less than 0.001 MeV. (See the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients for an explanation of terms and interpretation of radiation energies.) Values are given to two significant figures. Polonium-210 is a decay product of radium-226 and is also shown on that fact sheet. The basic properties of polonium-208 and polonium-209 (which are not in the natural decay series) are also given here because they are included in the general discussion below.

Where Does It Come From? Because it is produced during the decay of naturally ubiquitous uranium-238, polonium-210 is widely distributed in small amounts in the earth's crust. Although it can be produced by the chemical processing of uranium ores or minerals, uranium ores contain less than 0.1 mg polonium-210 per ton. Originally, polonium-210 was obtained from the rich pitchblende ore found in Bohemia, but it can also be obtained from aged radium salts that contain about 0.2 mg per gram of radium. Although a number of other polonium isotopes are present in the natural decay series, their short half-lives preclude any appreciable concentrations.

Due to its scarcity, polonium-210 is usually produced artificially in a nuclear reactor by bombarding bismuth-209 (a stable isotope) with neutrons. This forms radioactive bismuth-210, which has a half-life of 5 days. Bismuth-210 decays to polonium-210 through beta decay. Milligram amounts of polonium-210 have been produced by this method. The longer-lived isotopes polonium-209 (half-life 103 years) and polonium-208 (half-life 2.9 years) are also produced in reactors or particle accelerators, but these are very expensive.

How Is It Used? Polonium-210 is used mainly in static eliminators, which are devices designed to eliminate static electricity in machinery where it can be caused by processes such as paper rolling, manufacturing sheet plastics, and spinning synthetic fibers. The polonium-210 is generally electroplated onto a backing foil and inserted into a brush, tube, or other holder. Alpha particles from the polonium ionize adjacent air, and the air ions then neutralize static electricity on the surfaces in contact with the air. These devices generally need to be replaced every year because of the short half-life of this radioisotope. Polonium-210 is also used in brushes to remove dust from photographic films and camera lenses. Static eliminators typically contain from tens to hundreds of mCi (thousandth of a curie) of radioactivity. Polonium-210 can also be combined with beryllium to produce neutron sources, and in fact it was used as neutron-producing initiators of at least the first generation of atomic weapons. In addition, polonium-210 has been investigated as a heat source for thermoelectric power devices for space applications.

What's in the Environment? Polonium-210 is naturally present in all environmental media at very low concentrations. In soils, the concentration is similar to that of uranium, averaging about 1 pCi/g (or one trillionth curie per gram). Because polonium-210 is produced from the decay of radon-222 gas, it can be found in the atmosphere from which it is deposited on the earth's surface. Average annual air concentrations range from 0.005 to 0.04 pCi/m^3. Polonium-210 is also emitted to the atmosphere during the calcining of phosphate rock as part of the production of elemental phosphorous. Although direct root uptake by plants is generally small, polonium-210 can be deposited on broad-leaved vegetables. Deposition from the atmosphere on tobacco leaves results in elevated concentrations of polonium-210 in tobacco smoke, resulting in greater intakes in smokers compared to non-smokers. It is estimated that the average Western diet includes from 1 to 10 pCi of polonium-210 per day. Polonium-210 can be significantly elevated in residents of northern lands who subsist on reindeer that consume lichens, which absorb trace elements from the atmosphere.

What Happens to It in the Body? Polonium can be taken into the body by eating food, drinking water, or breathing air. Between 50% and 90% of the polonium taken in by ingestion will promptly leave the body in feces. The fraction remaining in the body enters the bloodstream. In general, the spleen and kidneys concentrate polonium more than other tissues except for temporary deposition in the lung after inhalation of an insoluble form. It is estimated that approximately 45% of ingested polonium will be deposited in the spleen, kidneys, and liver, with 10% deposited in bone marrow and the remainder distributed throughout the body. The amount of polonium in the body will decrease with a half-time of 50 days.

Studies of smokers have shown that inhaled polonium can be highly localized in the lungs, with about twice as much polonium found in the ribs of smokers compared to nonsmokers. It is estimated that the dose to the skeleton is elevated about 30% in smokers. Another source of polonium-210 in the body is its gradual ingrowth from the decay of radium-226 and lead-210 deposited in bone. The average amount of polonium-210 in the body is approximately 1 nCi (one billionth of a curie).

What Are the Primary Health Effects? Polonium-210 is a health hazard only if it is taken into the body. External exposure is not a concern because polonium is an alpha emitter. The primary means of exposure are ingestion of food and water containing polonium-210 and inhalation of polonium-contaminated dust. Inhalation is of particular concern in the vicinity of a source of airborne dust, such as a phosphate plant, and in areas of high radon concentrations, or for cigarette smokers.

Substantial radiation doses from polonium can be expected in many tissues of the body; it supplies a more nearly whole-body dose than almost all other alpha emitters. Effects are more common in the kidney than the spleen, despite a higher dose in the spleen. The lymph nodes and liver can also be affected. Polonium that is inhaled, either from radon in the air or cigarette smoke, can be deposited on the mucous lining of the respiratory tract. When alpha particles are then emitted within the lung, the cells lining the airways can be damaged, potentially leading to lung cancer over time.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including polonium-210 *(see box at right)*. Risk coefficients for inhalation are about 6 times higher than for dietary ingestion. Similar to other radionuclides, the risk coefficients for ingestion of tap water containing polonium-210 are about 75% of those shown for dietary ingestion. Polonium-210 poses no external risk when outside the body.

Radiological Risk Coefficients

This table provides risk coefficients for inhalation and absorption. Recommended default absorption types were used for inhalation, and dietary values were used for ingestion. Risks are for lifetime cancer mortality per unit intake (pCi), averaged over all ages and both genders (10^{-9} is a billionth). Other values, including for morbidity, are also available. No risk or dose conversion factors are available for Po-208 or Po-209.

Isotope	Lifetime Cancer Mortality Risk	
	Inhalation *(pCi^{-1})*	**Ingestion** *(pCi^{-1})*
Po-210	1.0×10^{-8}	1.6×10^{-9}

For more information, see the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients and the accompanying Table 1.