Protactinium - Pa

Chemical properties of protactinium - Health effects of protactinium - Environmental effects of protactinium

Atomic number	91
Atomic mass	231.0359 $g.mol^{-1}$
Electronegativity according to Pauling	1.5
Density	15.37 $g.cm^{-3}$ at 20°C
Melting point	1600 °C
Boiling point	unknown
Vanderwaals radius	unknown
Ionic radius	unknown
Isotopes	5
Electronic shell	[Rn] $5f^2$ $6d^1$ $7s^2$
Discovered by	K. Kajans and O.H. Gohring in 1913

Protactinium

Protactinium is a silver metallic element that belongs to the actinide group. It is malleable, shiny, silver-gray, radioactive. It does not tarnish rapidly in air, it is attacked by oxygen, steam and acids, but not by alkalis. It is superconductive at temperatures below 1.4 K.

Applications

Due to its scarcity, high radioactivity and toxicity, there are currently no uses for protactinium outside of basic scientific research.

Protactimium in the environment

Protactimium-231 occurs naturally in uranium ores such as pitchblende, to the extent of 3 ppm in some ores in Zaire. Protactinium is naturally present in soil, rock, surface water, groundwater, plants and animals in very low concentrations (on the order of 1 ppt or 0.1 picocouries (pCi)/g).

Health effects of protactinium

Protactinium does not play any biological role.

Protactinium can be taken into the body by eating food, drinking water, or breathing air. When protactinium is inhaled, a significant fraction can move from the lungs through the blood to other organs, depending on the solubility of the compound.

Gastrointestinal absorption from food or water is a likely source of internally deposited protactinium in the general population. Most of the protactinium taken in by ingestion will promptly leave the body in feces; only about 0.05% of the amount ingested is absorbed from the gastrointestinal tract into the bloodstream. After leaving the intestine or lung, about 40% of the protactinium that does enter the bloodstream deposits in the skeleton, about 15% deposits in the liver, about 2% deposits in the kidneys, and the rest is excreted. The biological half-life in the

skeleton is about 50 years. Of the protactinium deposited in the liver, 70% is assumed to be retained with a biological half-life of 10 days, with the remaining 30% having a biological half-life of 60 days. Of the protactinium deposited in the kidneys, 20% is assumed to be retained with a biological half-life of 10 days, with the remaining 80% having a biological half-redistribution.

Primary health effects: Protactinium is generally a health hazard only if it is taken into the body, although there is a small external risk associated with the gamma rays emitted by protactinium-231 and a number of short-lived decay products of actinium-227. The main means of exposure are ingestion of food and water containing protactinium and inhalation of protactinium-contaminated dust. Ingestion is generally the exposure of concern unless there is a nearby source of contaminated airborne dust. Because protactinium is taken up in the body much more readily if inhaled rather than ingested, both exposure routes can be important.

The major health concern is cancer resulting from the ionizing radiation emitted by protactinium deposited in the skeleton, liver, and kidneys. The health risks associated with protactinium-234m are included with those for uranium-238. Protactinium-234m decays by emitting an energetic beta particle so precautions against this radiation are needed when handling uranium; for example, heavy rubber gloves are worn to protect the hands and forearms.

The inhalation risk factor for protactinium-231 represents one of the largest risk factors for any radionuclide. Actinium-227 and its decay products account for more than 80% of this inhalation risk. While the risk factor for ingestion is much lower than for inhalation, ingestion is generally the most common means of entry into the body.

Similar to other radionuclides, the risk coefficient for tap water is about 75% of that shown for dietary ingestion.

In addition to risks from internal exposures, there is a risk from external gamma exposure to protactinium-231.

Using the external gamma risk coefficients to estimate lifetime cancer mortality risks, if it is assumed that 100,000 people were continuously exposed to a thick layer of soil with an initial average concentration of 1 pCi/g protactinium-231, then 8 of these 100,000 people would be predicted to incur a fatal cancer. As for internal exposures, much of this risk is from actinium-227 and its decay products.

Effects of protactinium on the environment

Protactinium preferentially adheres quite well to soil, and the concentration associated with sandy soil particles is typically 550 times higher than in interstitial water (water in the pore space between the soil particles); concentration ratios are even higher (about 2,000 and above) for loam and clay soils.

Protactinium is generally not a major contaminant at DOE (Department Of Energy) sites and is not a concern for groundwater.