- Uranium Properties

Uranium Atomic Symbol: U

atomic number 92

Atomic Weight: 238.0289

Word Origin: Named after the planet Uranus

(Element Classification: Radioactive Rare Earth Element (Actinide Series

Discovery: Martin Klaproth 1789 (Germany), Peligot 1841

Density (g/cc): 19.05

Melting Point (°K): 1405.5

Boiling Point (°K): 4018

Uranium generally has a valence of 6 or 4. Uranium is a heavy, lustrous, silvery-white metal, capable of taking a high polish. It exhibits three crystallographic modifications: alpha, beta, and gamma.

- Uranium

Uranium is a hard, dense, malleable, ductile, silver-white, radioactive metal. Uranium metal has very high density. When finely divided, it can react with cold water. In air it is coated by uranium oxide, tarnishing rapidly. It is attacked by steam and acids. Uranium can form solids solutions and intermetallic compounds with many of the .metals

Uranium was discovered by Martin Klaproth, a German chemist, in 1789 in the mineral pitchblende, and was named after the planet Uranus. It occurs in most rocks in concentrations of 2 to 4 parts per million and is as common in the Earth's crust as tin, tungsten and molybdenum and about 40 times as common as silver. It is also found in the oceans, at an average concentration of 1.3 parts per billion. There are a number of locations in different parts of the world where it occurs in economically-recoverable concentrations. When mined, it yields a mixed uranium oxide product, .U_3O_8. Uraninite, or pitchblende, is the most common uranium mineral

In the past, uranium was also used to colour glass (from as early as 79 AD) and deposits were once mined in order to obtain its decay product, radium. This element was used in luminous paint, particularly on the dials of watches and aircraft .instruments up to the 1950s, and in medicine for the treatment of disease

For many years from the 1940s, virtually all of the uranium that was mined was used in the production of nuclear weapons, but this ceased to be the case in the 1970s. Today the only substantial use for uranium is as fuel in nuclear reactors, mostly for electricity generation. Uranium-235 is the only naturally-occurring material which can .sustain a fission chain reaction, releasing large amounts of energy

While nuclear power is the predominant use of uranium, heat from nuclear fission can be used for industrial processes. It is also used for marine propulsion (mostly naval). .And small nuclear reactors are important for making radioisotopes

- Uranium Uses

Uranium is of great importance as a nuclear fuel. Nuclear fuels are used to generate electrical power, to make isotopes, and to make weapons. Much of the internal heat of the earth is thought to be due to the presence of uranium and thorium. Uranuim-238, with a half-life of 4.51 x 109 years, is used to estimate the age of igneous rocks. Uranium may be used to harden and strengthen steel. Uranium is used in inertial guidance devices, in gyro compasses, as counterweights for aircraft control surfaces, as ballast for missile reentry vehicles, for shielding, and for x-ray targets. The nitrate may be used as a photographic toner. The acetate is used in analytical chemistry. The natural presence of uranium in soils may be indicative of the presence of radon and its daughters. Uranium salts have been used for producing yellow 'vaseline' glass and ceramic glazes .

- Sources

Uranium occurs in minerals including pitchblende, carnotite, cleveite, autunite, uraninite, uranophane, and tobernite. It is also found in phosphate rock, lignite, and monazite sands. Radium is always associated with uranium ores. Uranium can be prepared by reducing uranium halides with alkali or alkaline earth metals or by reducing uranium oxides by calcium, carbon, or aluminum at elevated temperatures. The metal can be produced through electrolysis of KUF5 or UF4, dissolved in a molten mixture of CaCl2 and NaCl. High-purity uranium can be prepared by the .thermal decomposition of uranium halides on a hot filament

- Applications

Uranium gained importance with the development of practical uses of nuclear energy. Depleted uranium is used as shelding to protect tanks, and also in bullets and missiles. The first atomic bomb used in warfare was an uranium bomb. This bomb contained

enough of the uramium-235 isotope to start a runaway chain reaction which in a fraction of a second caused a large number of the uranium atoms to undergo fission, .there by releasing a fireball of energy

The main use of uranium in the civilian sector is to fuel commercial nuclear power plants. This require uranium to be enriched with the uranium-235 isotope and the chain reaction to be controlled so that the energy is released in a more manageable .way

The isotope uranium 238 is used to estimate the age of the earliest igneous rocks and .for other types of radiometric dating

Phosphate fertilizers are made from material typically high in uranium, so they .usually contain high amounts of it

- Uranium in the environment

Although uranium is radioactive, it is not particularly rare. It is widely spread throughout the environment and so it is impossible to avoid uranium. Uranium can be found naturally in the environment in very small amounts in rocks, soil, air and water. Humans add uranium metals and compounds, because they are released during mining .and milling processes

In air the uranium concentrations are very low. Even at higher than usual concentrations in air, there is so little uranium present per cubic meter that less than .one atom transfers every day

In water most of the uranium is dissolved uranium that derives from rocks and soil that the water runs over. Some of the uranium is suspended, so that the water gets a muddy texture. Only a very small part of uranium in water settles from air. The .amounts of uranium in drinking water are generally very low

Uranium is found in soils in varying concentrations that are usually very low. Humans .add uranium to the soil through industrial activities

Erosion of tailing from mines and mills may cause larger amounts of uranium to be released into the environment

- Health effects of uranium

People always experience exposure to a certain amount of uranium from food, air, soil and water, as it is naturally present in all these components. Food, such as root vegetables, and water will provide us with small amounts of natural uranium and we

will breathe in minimal concentrations of uranium with air. The concentrations of uranium in seafood are usually so low that they can be safely ignored.

People that live near hazardous waste sites, people that live near mines, people that work in the phosphate industry, people that eat crops grown on contaminated soil or people that drink water from a uranium waste disposal point may experience a higher exposure than other people. Uranium glazes are banned, but some artists that still use them for glasswork will experience a higher-than-usual exposure.

Because uranium is a radioactive substance health effects have been researched. Scientists have detected no harmful radiation effects of natural levels of uranium. However, chemical effects may occur after the uptake of large amounts of uranium and these can cause health effects such as kidney disease.

When people are exposed to uranium radionuclides that are formed during radioactive decay for a long period of time, they may develop cancer. The chances of getting cancer are much higher when people are exposed to enriched uranium, because that is a more radioactive form of uranium. This form of uranium gives off damaging radiation, which can cause people to develop cancer within a few years. Enriched uranium may end up in the environment during accidents in nuclear power plants.

Whether uranium can cause reproductive effects in people is currently unknown.

- Effects of uranium on the Environment

Uranium is a radioactive material that is very reactive. As a result it cannot be found in the environment in its elemental form. Uranium compounds that have consisted during reactions of uranium with other elements and substances dissolve in water to their own extend. The water-solubility of a uranium compound determines its mobility in the environment, as well as its toxicity.

While uranium itself is not particularly dangerous, some of its decay products do pose a threat, expecially radon, which can build up in confined spaces such as basements.

Uranium in air exists as dust that will fall into surface water, on plants or on soils through settling or rainfall. It will than sink to the sediment in water or to the lower soil layers, where it will mix with uranium that is already present.

Water containing low amounts of uranium is usually safe to drink. Because of its nature, uranium is not likely to accumulate in fish or vegetables and uranium that is absorbed will be eliminated quickly through urine and faeces.

The compounds in the soil will combine with other compounds, which can stay in the soil for years without moving towards the groundwater. Uranium concentrations are

often higher in phosphate-rich soil, but this does not have to be a problem, because .concentrations often do not exceed normal ranges for uncontaminated soil

Plants absorb uranium through their roots and store it there. Root vegetables such as radishes may contain higher than usual concentrations of uranium as a result. When the vegetables are washed the uranium will be removed

.

- Decay Chains

In nuclear science, the decay chain refers to the radioactive decay of different discrete radioactive decay products as a chained series of transformations. Most radioactive elements do not decay directly to a stable state, but rather undergo a series of decays until eventually a stable isotope is reached.

Decay stages are referred to by their relationship to previous or subsequent stages. A parent isotope is one that undergoes decay to form a daughter isotope. The daughter isotope may be stable or it may decay to form a daughter isotope of its own. The daughter of a daughter isotope is sometimes called a granddaughter isotope.

The four most common modes of radioactive decay are: alpha decay, beta minus decay, beta plus decay (considered as both positron emission and electron capture), and isomeric transition. Of these decay processes, alpha decay changes the atomic mass number (A) of the nucleus, and always decreases it by four. Because of this, almost any decay will result in a nucleus whose atomic mass number has the same residue mod 4, dividing all nuclides into four classes. The members of any possible decay chain must be drawn entirely from one of these classes. All four chains also produce helium, from alpha particles.

Three main decay chains (or families) are observed in nature, commonly called the thorium series, the radium series (not uranium series), and the actinium series, representing three of these four classes, and ending in three different, stable isotopes of lead. The mass number of every isotope in these chains can be represented as A=4n, A=4n+2, and A=4n+3, respectively. The long-lived starting isotopes 232Th, 238U, and 235U, respectively, of these three have existed since the formation of the earth. The plutonium isotopes Pu-244 and Pu-239 have also been found in trace amounts on earth.

*Radium Series - The Uranium^{238} Decay Chain

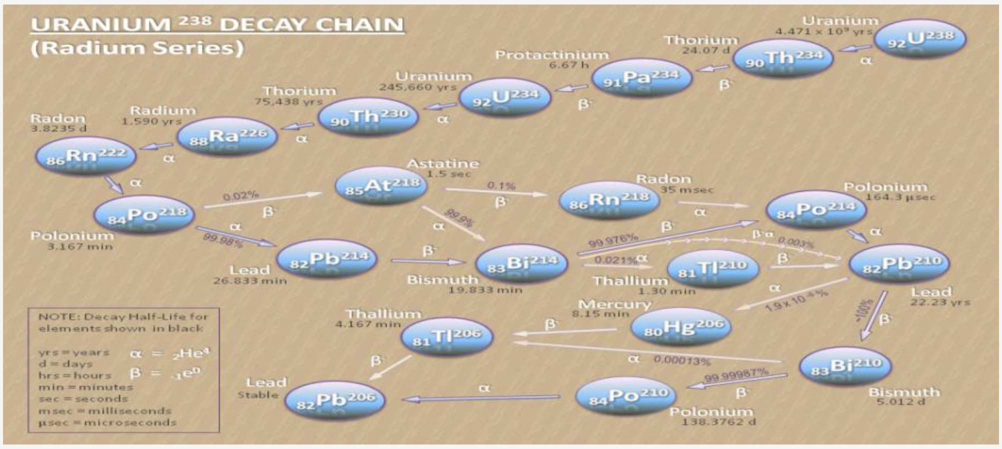
Beginning with naturally occurring uranium-238, this series includes the following elements: astatine, bismuth, lead, polonium, protactinium, radium, radon, thallium, and thorium. All are present, at least transiently, in any uranium-containing sample, whether metal, compound, or mineral

Uranium^{238} Decay Chain (Radium Series)

RE: www.periodictable.com

The 4n+2 chain of U-238 is commonly called the "Radium Series" (sometimes "Uranium Series").

Nuclide	Element Name	Historic Name	Decay Mode	Half Life	MeV	Product of Decay
$_{92}U^{238}$	Uranium - 238	*Uranium*	α	4.471 x 10^9 yrs	4.26975	$_{90}Th^{234}$
$_{90}Th^{234}$	Thorium - 234	*Uranium X1*	β^-	24.07 d	0.27309	$_{91}Pa^{234}$
$_{91}Pa^{234}$	Protactinium - 234	*Uranium Z*	β^-	6.67 h	2.194577	$_{92}U^{234}$
$_{92}U^{234}$	Uranium - 234	*Uranium two*	α	245,660 yrs	4.85773	$_{90}Th^{230}$
$_{90}Th^{230}$	Thorium - 230	*Ionium*	α	75,438 yrs	4.76996	$_{88}Ra^{226}$
$_{88}Ra^{226}$	Radium - 226	*Radium*	α	1,590 yrs	4.87062	$_{86}Rn^{222}$
$_{86}Rn^{222}$	Radon - 222	*Radon*	α	3.823495 d	5.59031	$_{84}Po^{218}$
$_{84}Po^{218}$	Polonium - 218	*Radium A*	α 99.98 % β^- 0.02 %	3.167 min	6.11468 0.2596	$_{82}Pb^{214}$ $_{85}At^{218}$
$_{85}At^{218}$	Astatine - 218	*Eka-Iodine, Dakin*	α 99.90 % β^- 0.10 %	1.5 s	6.874 2.8812	$_{83}Bi^{214}$ $_{86}Rn^{218}$
$_{86}Rn^{218}$	Radon - 218	*Actinon*	α	35 msec	7.26253	$_{84}Po^{214}$
$_{82}Pb^{214}$	Lead - 214	*Radium B*	β^-	26.833 min	1.0189	$_{83}Bi^{214}$
$_{83}Bi^{214}$	Bismuth - 214	*Radium C*	β^- 99.976 % α 0.021 % $\beta^-\alpha$ 0.003 %	19.833 min	3.2697 5.62119 11.1032	$_{84}Po^{214}$ $_{81}Tl^{210}$ $_{82}Pb^{210}$
$_{84}Po^{214}$	Polonium - 214	*Radium C'*	α	164.3 μsec	7.83346	$_{82}Pb^{210}$
$_{81}Tl^{210}$	Thallium - 210	*Radium C"*	β^- ~ 100%	1.30 min	5.482	$_{82}Pb^{210}$
$_{82}Pb^{210}$	Lead - 210	*Radium D*	β^- ~ 100% α 1.9 x 10^{-6}%	22.23 yrs	0.06486 3.7923	$_{83}Bi^{210}$ $_{80}Hg^{206}$
$_{83}Bi^{210}$	Bismuth - 210	*Radium E*	β^- 99.999878% α 0.000132%	5.012 d	1.161292 5.0364	$_{84}Po^{210}$ $_{81}Tl^{206}$
$_{84}Po^{210}$	Polonium - 210	*Radium F*	α	138.3762 d	5.40745	$_{82}Pb^{206}$
$_{80}Hg^{206}$	Mercury - 206		β^-	8.15 min	1.3076	$_{81}Tl^{206}$
$_{81}Tl^{206}$	Thallium - 206		β^-	4.167 min	1.532346	$_{82}Pb^{206}$
$_{82}Pb^{206}$	Lead - 206		-	stable	-	-



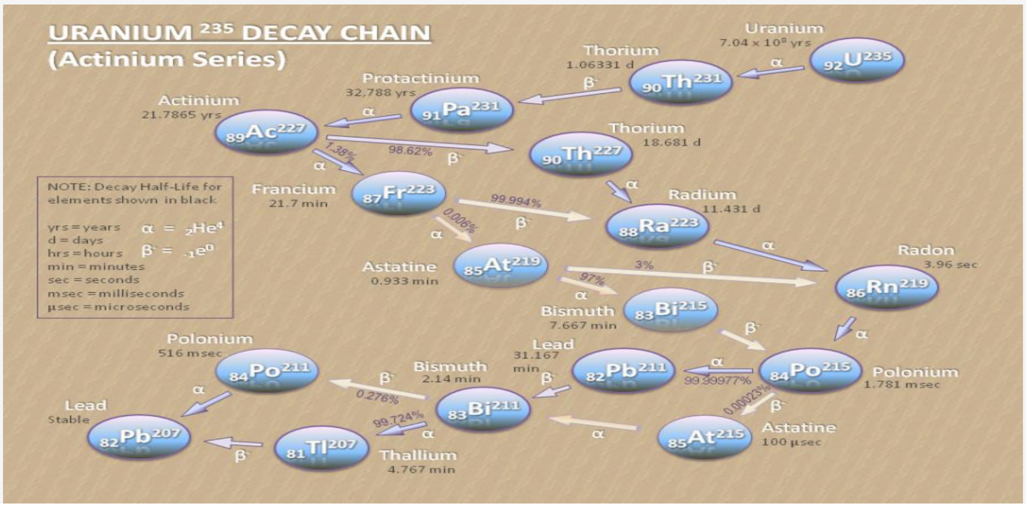
*Actinium Series - The Uranium^{235} Decay Chain

Beginning with naturally occurring uranium-235, this series includes the following elements: Actinium, astatine, bismuth, francium, lead, polonium, protactinium, radium, radon, thallium, and thorium. All are present, at least transiently, in any uranium-containing sample, whether metal, compound, ore, or mineral.

Uranium^{235} Decay Chain (Actinium Series) RE: www.periodictable.com

The 4n+2 chain of U^{235} is commonly called the "Actinium Series"

Nuclide	Element Name	Historic Name	Decay Mode	Half Life	MeV	Product of Decay
$_{92}U^{235}$	Uranium - 235	*Pitchblende, Actin Uranium*	α	7.04×10^8 yrs	4.67826	$_{90}Th^{231}$
$_{90}Th^{231}$	Thorium - 231	*Uranium Y*	β^-	1.06331 d	0.39156	$_{91}Pa^{231}$
$_{91}Pa^{231}$	Protactinium - 231	*Brevium*	α	32,788 yrs	5.14987	$_{89}Ac^{227}$
$_{89}Ac^{227}$	Actinium - 227	*Emanium*	β^- 98.62% α 1.38%	21.7865 yrs	0.044765 5.04219	$_{90}Th^{227}$ $_{87}Fr^{223}$
$_{90}Th^{227}$	Thorium - 227	*Radioactinium*	α	18.681 d	6.1466	$_{88}Ra^{223}$
$_{87}Fr^{223}$	Francium - 223	*Eka-Caesium, Actinium-K*	β^- 99.994% α 0.006%	21.7 min	1.149171 5.56187	$_{88}Ra^{223}$ $_{85}At^{219}$
$_{88}Ra^{223}$	Radium - 223	*Actinium X*	α	11.431 d	5.97899	$_{86}Rn^{219}$
$_{85}At^{219}$	Astatine - 219	*Eka-Iodine, Dakin*	α 97% β^- 3%	0.933 min	6.3236 1.5663	$_{83}Bi^{215}$ $_{86}Rn^{219}$
$_{86}Rn^{219}$	Radon - 219	*Actinon*	α	3.96 sec	6.94612	$_{84}Po^{215}$
$_{83}Bi^{215}$	Bismuth - 215		β^-	7.667 min	2.1888	$_{84}Po^{215}$
$_{84}Po^{215}$	Polonium - 215	*Actinium A*	α 99.99977% β^- 0.00023%	1.781 msec	7.52626 0.71484	$_{82}Pb^{211}$ $_{85}At^{215}$
$_{85}At^{215}$	Astatine - 215		α	100 μsec	8.17838	$_{83}Bi^{211}$
$_{82}Pb^{211}$	Lead - 211	*Actinium B*	β^-	31.167 min	1.36697	$_{83}Bi^{211}$
$_{83}Bi^{211}$	Bismuth - 211	*Actinium C*	α 99.724% β^- 0.276%	2.14 min	6.75033 0.57409	$_{81}Tl^{207}$ $_{84}Po^{211}$
$_{84}Po^{211}$	Polonium - 211	*Actinium C'*	α	516 msec	7.59448	$_{82}Pb^{207}$
$_{81}Tl^{207}$	Thallium - 207	*Actinium C"*	β^-	4.767 min	1.41824	$_{82}Pb^{207}$
$_{82}Pb^{207}$	Lead - 207		—	Stable	—	—



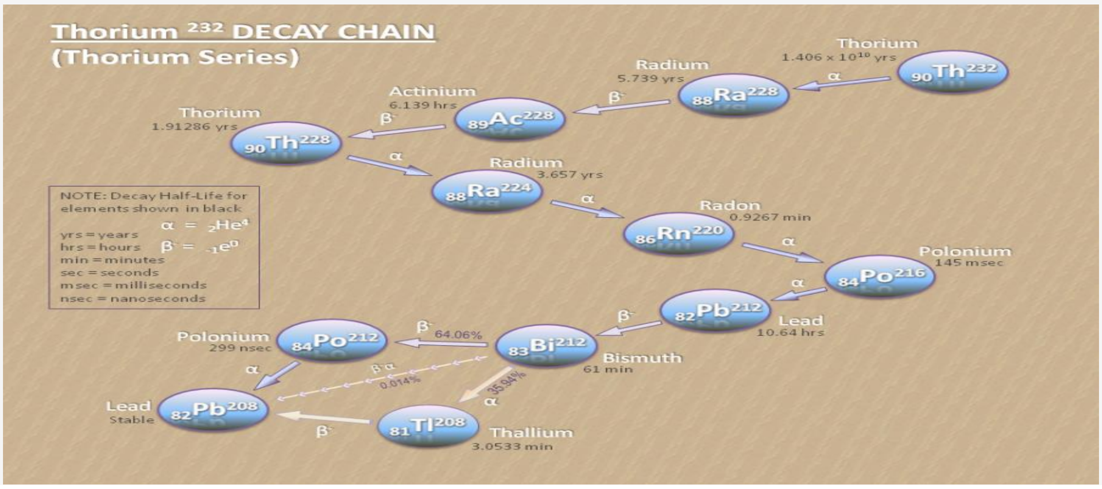
*Thorium Series - The Thorium^{232} Decay Chain

Begining with naturally occurring thorium-232, this series includes the following elements: Actinium, bismuth, lead, polonium, radium, and radon. All are present, at least transiently, in any natural thorium-containing sample, whether metal, compound, or mineral.

Thorium^{232} Decay Chain (Thorium Series)

[illegible]

Nuclide	Element Name	Historic Name	Decay Mode	Half Life	MeV	Product of Decay
$_{90}Th^{232}$	Thorium - 232	Thorium	α	[illegible] yrs	[illegible]	$_{88}Ra^{228}$
$_{88}Ra^{228}$	Radium - 228	[illegible]	β⁻	5.739 yrs	[illegible]	$_{89}Ac^{228}$
$_{89}Ac^{228}$	Actinium - 228	[illegible]	β⁻	[illegible] hrs	[illegible]	$_{90}Th^{228}$
$_{90}Th^{228}$	Thorium - 228	[illegible]	α	[illegible] yrs	[illegible]	$_{88}Ra^{224}$
$_{88}Ra^{224}$	Radium - 224	[illegible]	α	3.657 yrs	[illegible]	[illegible]
$_{86}Rn^{220}$	Radon - 220	[illegible]	α	0.9267 min	[illegible]	[illegible]
$_{84}Po^{216}$	Polonium - 216	[illegible]	α	145 msec	[illegible]	[illegible]
$_{82}Pb^{212}$	Lead - 212	[illegible]	β⁻	10.64 hrs	[illegible]	[illegible]
$_{83}Bi^{212}$	Bismuth - 212	[illegible]	[illegible]	61 min	[illegible]	[illegible]
$_{84}Po^{212}$	Polonium - 212	[illegible]	α	299 nsec	[illegible]	[illegible]
$_{81}Tl^{208}$	Thallium - 208	[illegible]	β⁻	3.0533 min	[illegible]	[illegible]
$_{82}Pb^{208}$	Lead - 208		—	Stable	—	—



-The most important isotopes Uranium and their characteristics and their environmental impacts

Isotopes: Uranium has sixteen isotopes. All of the isotopes are radioactive. Naturally-occurring uranium contains approximately 99.28305 by weight U-238, 0.7110% U-235, and 0.0054% U-234. The percentage weight of U-235 in natural uranium depends on its source and may vary by as much as 0.1%

*** Thorium** - is a chemical element with the symbol Th and atomic number 90. As a naturally occurring, slightly radioactive metal, it has been considered as an alternative nuclear fuel to uranium. When pure, thorium is a silvery-white metal that retains its luster for several months. However, when it is exposed to oxygen, thorium slowly tarnishes in air, becoming grey and eventually black. Thorium dioxide (ThO_2), also called thoria, has the highest melting point of any oxide (3300°C). Exposure to an aerosol of thorium can lead to increased risk of cancers of the lung, pancreas and .blood. Exposure to thorium internally leads to increased risk of liver diseases

***Protactinium** - is a chemical element with the symbol Pa and atomic number 91. Its longest-lived isotope has a half-life of 32,760 years. Due to its scarcity, high radioactivity, and toxicity, there are currently no uses for protactinium outside of basic scientific research. Protactinium occurs in pitchblende to the extent of about 1 part 231Pa per 10 million parts of ore (i.e., 0.1 ppm). Protactinium is both toxic and highly radioactive. It requires precautions similar to those used when handling .plutonium

***Actinium -** is a radioactive chemical element with the symbol Ac and atomic number 89, which was discovered in 1899. Actinium is a silvery, radioactive, metallic element. Due to its intense radioactivity, actinium glows in the dark with a pale blue light. The chemical behavior of actinium is similar to that of the rare earth element lanthanum. 227Ac is extremely radioactive, and in terms of its potential for radiation induced health effects[15] 227Ac is even more dangerous than plutonium. .Ingesting even small amounts of 227Ac would be fatal

***Radium -** is a radioactive chemical element which has the symbol Ra and atomic number 88. Its appearance is almost pure white, but it readily oxidizes on exposure to air, turning black. Radium is an alkaline earth metal that is found in trace amounts in

uranium ores. It is extremely radioactive. Radium is a decay product of uranium and is therefore found in all uranium-bearing ores. Radium is highly radioactive and its decay product, radon gas, is also radioactive. Since radium is chemically similar to calcium, it has the potential to cause great harm by replacing it in bones. Inhalation, .injection, ingestion or body exposure to radium can cause cancer and other disorders

***Radon -** is a chemical element with symbol Rn and atomic number 86. Radon is a colorless, odorless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is one of the heaviest substances that remains a gas under normal conditions and is considered to be a health hazard. Radon is a significant contaminant that affects indoor air quality worldwide. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement. Radon can be found in some spring waters and hot springs. According to the United States Environmental Protection Agency, radon is reportedly the second most frequent cause of lung cancer, after cigarette smoking; and radon-induced lung cancer the 6th leading cause of cancer death overall. According to the same sources, radon reportedly causes .21,000 lung cancer deaths per year in the United States

***Polonium -** is a chemical element with the symbol Po and atomic number 84, discovered in 1898 by Marie and Pierre Curie. A rare and highly radioactive metalloid,[1] polonium is chemically similar to bismuth[2] and tellurium, and it occurs in uranium ores. By mass, polonium-210 is around 250,000 times more toxic than hydrogen cyanide (the actual LD50 for 210Po is about 1 microgram for an 80 kg person (see below) compared with about 250 milligrams for hydrogen cyanide). It has been estimated that a median lethal dose of 210Po is 0.015 GBq (0.4 millicuries), .or 0.089 micrograms, still an extremely small amount

***Lead -** is a main-group element with symbol Pb (Latin: plumbum) and atomic number 82. Lead is a soft, malleable poor metal, also considered to be one of the heavy metals. Lead has a bluish-white color when freshly cut, but tarnishes to a dull grayish color when exposed to air. It has a shiny chrome-silver luster when melted into a liquid. Lead has the highest atomic number of all stable elements, although the next element, bismuth, has a half-life so long (longer than the estimated age of the universe) it can be considered stable. Like mercury, another heavy metal, lead is a potent neurotoxin that accumulates in soft tissues and bone over time. Lead is a poisonous metal that can damage nervous connections (especially in young children) .and cause blood and brain disorders

***Molybdenum -** from the Greek word for the metal "lead"), is a Group 6 chemical element with the symbol Mo and atomic number 42. It has the eighth-highest melting point of any element. It readily forms hard, stable carbides, and for this reason it is often used in high-strength steel alloys. Molybdenum is found in trace amounts in plants and animals, although excess molybdenum can be toxic in some animals.The ability of molybdenum to withstand extreme temperatures without significantly expanding or softening makes it useful in applications that involve intense heat, including the manufacture of aircraft parts, electrical contacts, industrial motors, and filaments. Molybdenum dusts and fumes, as can be generated by mining or metalworking, can be toxic, especially if ingested (including dust trapped in the sinuses and later swallowed).Low levels of prolonged exposure can cause irritation to the eyes and skin. The direct inhalation or ingestion of molybdenum and its oxides should also be avoided. Chronic exposure to 60 to 600 mg Mo/m³ can cause .symptoms including fatigue, headaches, and joint pains

***Vanadium -** is the chemical element with the symbol V and atomic number 23. It is a soft, ductile, silver-grey metal. Most vanadium is used as ferrovanadium as an additive to improve steels. All vanadium compounds should be considered to be toxic. The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 0.05 mg/m3 for vanadium pentoxide dust and 0.1 mg/m3 for vanadium pentoxide fumes in workplace air for an 8-hour workday, 40-hour work week. The National Institute for Occupational Safety and Health (NIOSH) has recommended that 35 mg/m3 of vanadium be considered immediately dangerous to life and health. This is the exposure level of a chemical that is likely to cause .permanent health problems or death