Sound of Science
(理聲)

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How much do you know about Uranium?

Uranium is a radioactive element that occurs naturally in low concentrations (a few parts per million) in soil, rock, and surface and groundwater. It is the heaviest naturally occurring element, with an atomic number of 92. Uranium in its pure form is a silver-colored heavy metal that is nearly twice as dense as lead and is pyrophoric when finely divided.

Uranium exhibits three crystallographic modifications as follows: alpha --(688°C)→ beta --(776°C)→ gamma. It is a little softer than steel, and is attacked by cold water in a finely divided state. It is malleable, ductile, and slightly paramagnetic. In air, the metal becomes coated with a layer of oxide. Acids dissolve the metal, but it is unaffected by alkalis.

History

The name derives from the planet Uranus, which in Roman mythology was "Father Heaven". Uranium was found to be first used in yellow-colored glass, which contained more then 1% uranium oxide, dating back to 79 A.D. found near Naples, Italy. The metal was first isolated in 1841 by the French chemist Eugene-Melchior Peligot, who reduced the anhydrous chloride with potassium. The German chemist Martin Heinrich Klaproth discovered the element in 1789 when he recognized an unknown element in the mineral pitchblende, following the German/English astronomer William Hershel's discovery of the planet in 1781.

Uranium was apparently formed in super novae about 6.6 billion years ago, a decay product of elements with higher atomic weight, which may have once been present on Earth or elsewhere in the universe. It occurs in most rocks in concentrations of 2 to 4 parts per million, and in much lower concentrations in seawater. Its radioactive decay provides the main source of heat inside the Earth, causing convection and continental drift.

Uses

Uranium is of great importance as a nuclear fuel. Uranium-238 (^{238}U) can be converted into fissionable plutonium by the following reactions:

^{238}U(n, gamma) → ^{239}U -- (beta) → ^{239}Np -- (beta)→ ^{239}Pu.

This nuclear conversion can be brought about in breeder reactors where it is possible to produce more new fissionable material than the fissionable material used in maintaining the chain reaction.

Uranium-235 (^{235}U) is of even greater importance because it is the key to utilizing uranium. ^{235}U, while occuring in natural uranium to the extent of only 0.71%, is so fissionable with slow neutrons that a self-sustaining fission chain reaction can be made in a nuclear reactor constructed from natural uranium and a suitable moderator, such as heavy water or graphite, alone.

Uranium-235 can be concentrated by gaseous diffusion and other physical processes, if desired, and used directly as a nuclear fuel, instead of natural uranium, or used as an explosive. Natural uranium, slightly enriched with ^{235}U by a small percentage, is used to fuel nuclear power reactors to generate electricity. Natural thorium can be irradiated with neutrons as follows to produce the important isotope ^{233}U:

^{232}Th(n, gamma) → ^{233}Th -- (beta) → ^{233}Pa -- (beta) → ^{233}U.

While thorium itself is not fissionable, ^{233}U is, and in this way may be used as a nuclear fuel. One pound of completely fissioned uranium has the fuel value of over 1500 tons of coal.

The uses of nuclear fuels to generate electrical power, to make isotopes for peaceful purposes, and to make explosives are well known. The estimated world-wide capacity of the 429 nuclear power reactors in operation in January 1990 amounted to about 311,000 megawatts. Uranium in the U. S. is controlled by the U. S. Nuclear Regulatory Commission. New uses are being found for depleted uranium, i.e., uranium with the percentage of ^{235}U lowered to about 0.2%.

Uranium is used in inertial guidance devices, in gyro compasses, as counterweights for aircraft control surfaces, as ballast for missile reentry vehicles, and as a shielding material. Uranium metal is used for X-ray targets for production of high-energy X-rays; the nitrate has been used as a photographic toner, and the acetate is used in analytical chemistry.

Crystals of uranium nitrate are triboluminescent. Uranium salts have also been used for producing yellow "vaseline" glass and glazes. Uranium and its compounds are highly toxic, both from a chemical and radiological standpoint.

Sources

Uranium, not as rare as once thought, is now considered to be more plentiful than mercury, antimony, silver, or cadmium, and is about as abundant as molybdenum or arsenic. It occurs in numerous minerals such as pitchblende, uraninite, carnotite, autunite, uranophane, and tobernite. It is also found in phosphate rock, lignite, monazite sands, and can be recovered commercially from these sources.

The United States Department of Energy purchases uranium in the form of acceptable triuranium octaoxide (U_3O_8) concentrates. This incentive program has greatly increased the known uranium reserves. Uranium can be prepared by reducing uranium halides with alkali or alkaline earth metals or by reducing uranium oxides by calcium, aluminum, or carbon at high temperatures. The metal can also be produced by electrolysis of KUF_5 or uranium tetrafluoride (UF_4), dissolved in a molten mixture of calcium chloride ($CaCl_2$) and sodium chloride

(NaCl). High-purity uranium can be prepared by the thermal decomposition of uranium halides on a hot filament.

Isotopes

Uranium has sixteen isotopes, all of which are radioactive. Naturally occurring uranium nominally contains 99.28305% by weight ^{238}U, 0.7110% ^{235}U, and 0.0054% ^{234}U. Studies show that the percentage weight of ^{235}U in natural uranium varies by as much as 0.1%, depending on the source. The U. S. Department of Energy has adopted the value of 0.711 as being their official percentage of ^{235}U in natural uranium. Natural uranium is sufficiently radioactive to expose a photographic plate in an hour or so. Much of the internal heat of the Earth is thought to be attributable to the presence of uranium and thorium.

Uranium is naturally radioactive, which means that atoms of uranium are unstable and decay by emitting articles and energy. Uranium decays very slowly by emitting an alpha particle. The half-life of uranium-238 is about 4.5 billion years, which means it is not very radioactive. In fact, its very long half-life (and thus low radioactivity) is the reason uranium still exists on the Earth. Three additional isotopes of uranium are not naturally present but can be produced by nuclear transformations. These are uranium-232, uranium-233, and uranium-236. Like the natural uranium isotopes, these three also decay by emitting an alpha particle.

The isotope ^{235}U is important because under certain conditions it can readily be split, yielding a lot of energy. When the nucleus of a ^{235}U atom captures a neutron it splits in two (fissions), releases energy in the form of heat, and emits two or three neutrons. If enough of these expelled neutrons cause the nuclei of other ^{235}U atoms to split, releasing further neutrons, a fission ‘chain reaction’ can be achieved. This is the process that occurs in a nuclear reactor where the heat is used to make steam to produce electricity. Each fission of a ^{235}U atom releases about 200 MeV (3.2 x 10^{-11} joule)—about 50 million times as much energy as burning an atom of carbon. In other terms, a kilogram of natural uranium used in a typical reactor yields around 20,000 times as much energy as a kilogram of coal, and a kilogram of enriched nuclear fuel yields 160,000 times as much. Fission produces hundreds of different kinds of fission products (isotopes of much lighter elements), most of which are radioactive. In addition, a uranium atom may capture a neutron without splitting, leading the formation of a number of radioactive transuranic elements. These byproducts comprise nuclear waste.

Related photos: Uranium ore, glowing uranium in the dark

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Relaxing Time

6	7		2					
	2				1			
	1			7		7		2
	4			2		3		8
2	5						4	1
8		9						
5		1						
			6				5	
					5		1	9

Answer

6	7	3	2	5	8	1	9	4
4	2	8	7	9	1	5	3	6
9	1	5	3	4	6	7	8	2
1	4	7	5	2	9	3	6	8
2	5	6	8	3	7	9	4	1
8	3	9	1	6	4	2	7	5
5	6	1	9	8	3	4	2	7
7	9	4	6	1	2	8	5	3
3	8	2	4	7	5	6	1	9

Comic strip

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