Krypton-85

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Krypton 85 (^{85}**Kr**) is a radioisotope of krypton.

It decays into stable rubidium-85, with a half-life of 10.756 years and a maximum decay energy of 0.687 MeV. Its most common decay (99.57%) is by beta particle emission with maximum energy of 687 keV and an average energy of 251 keV. The second most common (0.43%) is by beta particle emission (maximum energy of 173 keV) followed by gamma ray emission (energy of 514 keV).[1][2]

Medium-lived fission products

Prop:	$t^{1/2}$	Yield	Q *	βγ
Unit:	a	%	keV	*
^{155}Eu	4.76	.0803	252	βγ
^{85}Kr	10.76	.2180	687	βγ
^{113m}Cd	14.1	.0008	316	β
^{90}Sr	28.9	4.505	2826	**β**
^{137}Cs	30.23	6.337	1176	βγ
^{121m}Sn	43.9	.00005	390	βγ
^{151}Sm	90	.5314	77	β

Krypton-85 Full table	
General	
Name, symbol	Krypton-85, ^{85}Kr
Neutrons	49
Protons	36
Nuclide data	
Half-life	10.756 years
Isotope mass	84.9125273(21) u
Spin	9/2+
Decay mode	**Decay energy**
Beta decay	0.687 MeV

In terms of radiotoxicity, 440 Bq of Kr-85 is equivalent to 1 Bq of radon-222, without considering the rest of the radon decay chain.

Other decay modes have very small probabilities and emit less energetic gammas.[3] The only other long-lived radioisotope of krypton is krypton-81 with a 210,000 year half-life; others have half-lives of less than two days.

Krypton-85 is produced in small quantities by the interaction of cosmic rays with the stable krypton-84 (which is present in concentrations of about 1 cm^3 per cubic meter). However, since the mid-1940s, much larger quantities have been artificially produced as a product of nuclear fission. When uranium-235, or another fissile nucleus fissions, it usually splits into two large fragments (fission products) with mass numbers around 90-140, and two or three neutrons. About three atoms of krypton-85 are produced for every 1000 fissions (i.e. it has a fission yield of 0.3%).[4] This is only about 20% of the total fission product of mass 85, as most decay from a short-lived excited state of ^{85}Kr directly to ^{85}Rb without passing through the longer-lived nuclear isomer.

About 5 megacuries (190 PBq) of the isotope was released into the atmosphere as a result of nuclear weapons tests between 1945 and the end of atmospheric testing in 1962. The 1979 accident at the Three Mile Island nuclear power plant released about 50 kilocuries (1,900 TBq) of Kr-85 into the atmosphere[4] and the Chernobyl accident released about 5 megacuries (190 PBq).[5] The atmospheric concentration of krypton-85 peaked in around 1970, when it reached around 10 pCi/m^3 (around 0.4 Bq/m^3). Since then the cessation of atmospheric weapons tests and the reduced production of plutonium has, because of the short half-life of the isotope, led to a sharp reduction in the atmospheric concentration, according to the Human Health Fact Sheet.

For wide-area atmospheric monitoring, krypton-85 is the best indicator for clandestine plutonium separations.[6]

A large nuclear power plant produces about 300 kilocuries (11,000 TBq) of the isotope per year, most or all retained in the spent nuclear fuel rods. Nuclear reprocessing currently releases Kr-85 to the atmosphere when the spent fuel is dissolved. It would also be possible to capture and store it as nuclear waste or for use.

Uses in Industry

It is used in arc discharge lamps commonly used in the entertainment industry for large HMI film lights as well as High Intensity Discharge lamps for outdoor lighting.[7] The existence of Kr-85 in discharge tube of the lamps can make the lamps easy to ignite.[8]

The sealed spark gap assemblies contained in ignition excitors used in some older turbine/jet engines contain a very small amount of krypton-85 in order to obtain consistent ionization levels and uniform operation. The amount of radiation from the average gap is approximately the same as that of a radium-dial wrist watch but should be handled carefully.

Krypton-85 was used in cold-cathode voltage regulator electron tubes, such as the type 5651.[9]

Krypton-85 is used to inspect aircraft components for small defects. Krypton-85 is allowed to penetrate small cracks, and then its presence is detected by autoradiography. The method is called "krypton gas penetrant imaging". The gas penetrates smaller openings than the liquids used in dye penetrant inspection and fluorescent penetrant inspection.[10]

Krypton-85 is used to test for leaks in semiconductors (MIL-STD-883H) and piping.

See also

- Krypton
- Isotopes of krypton

Footnotes

1. ^ Pinellas Plant – Occupational Environmental Dose (http://www.cdc.gov/niosh/ocas/pdfs/tbd/pine4.pdf)
2. ^ Pinellas Plant – Occupational Environmental Dose rev1 (http://www.cdc.gov/niosh/ocas/pdfs/tbd/pine4-r1.pdf)
3. ^ Kr-85 Decay Radiation Results (http://www.nndc.bnl.gov/chart/decaysearchdirect.jsp?nuc=85KR&unc=nds)
4. ^ ***a*** ***b*** "Human Health Fact Sheet: Krypton" (http://www.ead.anl.gov/pub/doc/krypton.pdf) (PDF). *Argonne National Laboratory*. August 2005. http://www.ead.anl.gov/pub/doc/krypton.pdf. Retrieved 2006-11-25.
5. ^ Chernobyl Disaster (http://hyperphysics.phy-astr.gsu.edu/Hbase/NucEne/cherno2.html)
6. ^ Conclusions on plutonium separation from atmospheric krypton-85 measured at various distances from the Karlsruhe reprocessing plant (http://www.sciencedirect.com/science/article/pii/S0265931X03002534)
7. ^ Krypton-85 (PDF) (http://www.spectragases.com/AssetMgmt/getDocument.aspx?assetid=618)
8. ^ Lamp types (http://www.elcfed.org/2_lighting_types.html)
9. ^ 5651 Sylvania Voltage Regulator Stabilizer Electron Tube (http://www.oddmix.com/tubes/5651.html)
10. ^ Krypton Gas Penetrant Imaging - A Valuable Tool for Ensuring Structural Integrity in Aircraft Engine Components (http://www.asnt.org/publications/materialseval/solution/decsolutions/decsolutions.htm)

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