

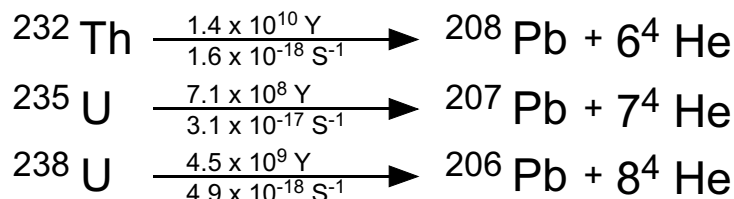
Helium is the sixth most abundant gas found in the earth's atmosphere (Table 1). It is an inert gas and very mobile, mixing rapidly. When the alpha particles from the radioactive decay of uranium and thorium pick up two electrons, atoms of the isotope helium-4 are formed. Several helium-4 atoms are produced from each decay series of U-238, U-235, and Th-232 (fig. 1). The half-lives of the parent isotopes are also shown in figure 1. One gram of uranium will produce  $\sim 10^5$  atoms of helium-4 per second, and one gram of thorium produces  $\sim 2.5 \times 10^4$  atoms of helium-4 per second (fig. 2). Calculations of the helium produced from the crust and mantle reveal that  $1,125 \times 10^{30}$  atoms per year are produced, but only  $7 \times 10^{30}$  atoms per year escape from the earth (Damon and Kulp, 1958). More is being produced than is being lost; in fact, the total atmospheric content of helium could be produced in only 2 million years (MacDonald, 1963)! However, all the crustal and mantle helium-4 does not degas into the atmosphere as it is formed. It is trapped in crystal lattices and in pore spaces within the earth. What this means is that there is excess helium-4 in the earth -- excess, that is, compared to the atmospheric concentration in equilibrium with the helium-4 escape rate into space and the helium-4 flux from the crust and mantle (Nicolet, 1957). Near-surface pockets of high helium-4 concentrations are known, and some natural gas fields are so enriched that they are the source for commercial production of helium.

**Table 1.** -- Average composition of the atmosphere, by volume, in parts per million (Mason, 1966)

N <sub>2</sub>	780,900	78.08776%
O <sub>2</sub>	209,500	20.94939%
Ar	9,300	0.929973%
CO <sub>2</sub>	300	0.029999%
Ne	18	0.001799%
He	5.2	0.000520%
CH <sub>4</sub>	1.5	0.000150%
Kr	1	0.000100%
N <sub>2</sub> O	0.5	0.000050%
H <sub>2</sub>	0.5	0.000050%
O <sub>3</sub>	0.4	0.000040%
Xe	0.08	0.000008%

**Figure 1.** -- Number of helium-4 atoms produced from the decay of uranium and thorium.

Y = years, S = seconds



**Figure 2.** -- Rate of helium-4 production from uranium and thorium

Helium-4 production from uranium and thorium

$$1.03 \times 10^5 \text{ He atoms} \cdot \text{sec}^{-1} = 1 \text{ gm U}$$

$$2.46 \times 10^4 \text{ He atoms} \cdot \text{sec}^{-1} = 1 \text{ gm Th}$$

Crust and mantle production of helium

$$1125 \times 10^{30} \text{ He atoms} \cdot \text{yr}^{-1}$$

Loss of helium to space

$$7 \times 10^{30} \text{ He atoms} \cdot \text{yr}^{-1}$$