Nuclear Fuel Cycle

NUGN506 - LME1

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CHAPTER 1

LEARNING MEASUREMENT 1

The extra-credit problems for the first learning measurement exercise is tackled in this document.

1.1 Extra Credit

1.1.1 Problem

Thermal neutron fission of U-235 produces nuclides of the A = 132 isobar in 4.31% of all fissions. This isobar includes the radioactive doubly-magic nuclide Sn-132 with Z = 50, N = 82 and a half-life of 39.7 seconds, but Te-132 has the highest independent fission yield for A = 132. Why aren't significant amounts of Cs-132 and Ba-132 (or Cs-131 or Ba-133 for the A = 131 or A = 133 isobars, respectively) observed in the cumulative fission yield when neighboring nuclides like Cs-133 and Ba-134 are? [Hint: It has nothing to do with magic numbers as Te-132 is the most probable fission product.]

1.1.2 Solution

The cumulative fission yield is different from the independent fission yield. The cumulativie fission yield also consider the decay of the precursors to form a nuclide of interest. In our case, we know that Te-132 has the highest independent fission yield for $A = 132$. According the the chart of the nuclides, it beta decay to I-132, I-132 then can beta decay to a stable Xe-132, or lose its excited state. Consequently, this decay chain does not produce any element with more protons than Xenon, and thus no Cs-133 or Ba-133. Similarly for $A = 131$ or $A = 133$, the decay chains stop at the elements Xe-131 and Cs-133 respectively.

Consequently, the cumulative fission yield for A132-isobars Cs-132 and Ba-132 are "only" their independent fission yield. In the meantime, Cs-133 and Ba-134 can also be created by the $\beta-$ decay chains:

$$^{133}I \rightarrow {}^{133}Xe \rightarrow {}^{133}Cs \tag{1.1}$$

$$^{134}Cs \rightarrow {}^{134}Ba \tag{1.2}$$

BIBLIOGRAPHY