Nuclear Engineering 150 – Discussion Section
Team Exercise Solutions #3

Problem 1

A reactor is operating for a long time at some known power density P_0. Then, it instantaneously changes power to some power density P_1. One fission product of interest is ^{135}Xe, though it has a neglible yield from the initial fission reaction. ^{135}Xe precursors ^{135}Te and ^{135}I are produced with a combined yield of approximately 6%, before decaying via β^- decay to ^{135}I and ^{135}Xe respectively. Find the number density of ^{135}Xe as a function of time after the power change. Let Q_f be the energy produced per fission, approximately 200 MeV.

Nucleus	Half-life	Thermal σ_a
^{135}Te	19.0 s	~ 0
^{135}I	6.6 hr	~ 0
^{135}Xe	9.2 hr	2.6×10^6 barns

Problem 1 Solution

We will create the following simple decay chain graphic, built from the information provided in the problem, to visualize the processes described in the problem.

GRAPHIC GRAPHIC

Starting off, since this is a problem related to decay, we will start from the usual equation for changes in a quantity of radionuclides.

$$\frac{dN}{dt} = \text{production} - \text{losses}$$

First, we find the neutron production. We are told that after the transition, the reactor is now generating with power density P_1.

The amount of ^{135}Xe is dependent on its parents, ^{135}Te and ^{135}I. Since the half-life of ^{135}Te (19.0 s) is practically insignificant in comparison to the multi-hour half-lives of its daughters (to be exact, $T_{1/2,\text{Te135}} = 0.08\, T_{1/2,\text{I135}}$ and $T_{1/2,\text{Te135}} = 0.06\, T_{1/2,\text{Xe135}}$), we can treat it as instantaneously decaying into iodine.

Now, we can recognize

Problem 2

Text of problem 2

Problem 2 Solution