Quiz#2

1. A mass of 4 kg of slightly enriched uranium fuel composed of (2% U-235, 98% U-238) is exposed for 30 days in a reactor operating at heat power 1MW. Neglecting consumption of U-238, what is the final fuel composition (enrichment)?Given:

- Atomic weight of uranium= 235 grams/mole
- Consider 3.3x1010 fissions per joule
- Avogadro's number NA= 6.023x1023 atoms/mole
- 86% of the neutrons absorbed by U-235 result in fission reactions.

6 points

2. Briefly define prompt and delayed neutrons? Explain the role of delayed neutrons in the reactor. 4 Points

(1) $1\ MW = 1\ \frac{MJ}{s}$, Find the amount of energy in joules consumed in 30 days

Energy in joules $= 1\ \frac{MJ}{s} \times 10^6 \frac{J}{MJ} \times$ (number of seconds in 30 days)

$= 10^6 \frac{J}{s} * (30 \times 24 \times 60 \times 60) = 2.6 \times 10^{12}$ Joules

Number of fissions needed to produce 2.6×10^{12} joules

$= 2.6 \times 10^{12} J * 3.3 \times 10^{10} \frac{\text{fissions}}{J} = 8.58 \times 10^{22}$ Fissions

i.e. one would need 8.58×10^{22} U-235 atoms to fission to produce the required amount of energy. We also know that only 86% of the consumed (burned) U-235 atoms undergo fission reaction

∴ Total # of consumed U-235 atoms $= \frac{8.58 \times 10^{22}}{0.86} = 9.98 \times 10^{22}$ atoms

Convert # of U-235 atoms to mass

mass of consumed U-235 $= \frac{9.98 \times 10^{22} \times 235}{6.023 \times 10^{23}} = 38.92$ grams

The original amount of U-235 in fuel $= 4\ kg * 0.02 = 0.08\ kg = 80$ grams

out of the 80 grams of U-235 originally existed in fuel, 38.92 grams was consumed in 30 days, and $80 - 38.92 = 41.08$ g remain intact

∴ enrichment after 30 days $= \frac{41.08}{4000} = 0.01027 = 1.027\%$ #

(2) A typical answer should convey the following:-

- prompt neutrons come instantly out of the fission reaction at the reaction site. The vast majority of the neutron population are prompt neutrons. They have very short life cycle compared to delayed neutrons
- Delayed neutrons are the result of decay of fission products. They comprise a tiny fraction of the neutron population. They have much longer life span compared to prompt neutrons.

- Due to their longer life cycle, delayed neutron essentially prolong the average life cycle of a neutron generation. that will lead to a rate of power increase slow enough such that the control system be able to cope with the rate of power change.