Principles of Heat Generation in Thermal Reactors

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1 Quiz

1.1 *Questions*

1. What is the recoverable amount of energy released per fission event?

2. The component of the reactor where majority of fission heat is deposited is
(a) moderator (b) fuel (c) structural elements (d) control rod

3. Determine the number of U-235 nuclei in 1 kg of 2.5 % enriched UO_2 fuel. The molecular weight of Uranium dioxide is 270.

4. Determine the specific power and power density of 2.5 % enriched UO_2 fuel in a heavy water reactor. The average neutron flux is $4x10^{13}$ $cm^{-2}s^{-1}$. The fission cross section is 579 b. The density of UO_2 is 18900 kg/m^3.

5. How is 1 MeV in Joule?

1.2 *Answers*

1. 200 MeV

2. (b) fuel

3. From the molecular weight of UO_2 (270) and the atomic weight of Uranium (238), one may calculated the mass of uranium in one kg of UO_2 as follows:

Mass of Uranium in 1 kg of UO_2 = 238/270 = 0.88 kg

Number of moles of Uranium in 1 kg of UO_2= 0.88/238 = 3.697 mole

Recalling the definition of one mole, there are Avagadro number (6.023×10^{23}) of atoms or nuclei per mole of a substance.

Therefore, one kg of UO_2 contains 2.227×10^{24} atoms.

Mass fraction of U-235 is 0.025 or in terms of percentage ~ 2.5 %

Atomic % of U-235 = (mass % of U-235/235)/(mass % of U-235/235+ mass % of U-238/238)

Atomic % of U-235 = (2.5/235)/(2.5/235+97.5/238) = 0.0253

Therefore, one kg of natural UO_2 contains 2.227×10^{24} atoms*0.0253 = 5.6368×10^{22} atoms.

4. Writing Eq. (10) again, we have

$P' = E_f N_f \phi \sigma_f$

$E_f = 200$ MeV $= 3.2 \times 10^{-11}$ J; $\phi = 4 \times 10^{13}$ $cm^{-2}s^{-1}$; $\sigma_f = 579$ b $= 579 * 10^{-28}$ cm^2

From the previous problem, the number of U-235 atoms in1 kg of 2.5 % fuel is 5.6368×10^{22} atoms/kg

Therefore, P' = 42019 W/kg = 42.02 kW/kg

$P'' = P' r_f$

P'' = 794.16 MW/m^3

5. 1 MeV = 1.609×10^{-13} J