(21.2) Using the data for the Würgassen reactor and the thermal neutron capture cross-section (Table 19.4) it can be calculated how many kg Pu should be formed per t U at a burn-up of 27 500 MWd/t. (a) Make this calculation assuming that plutonium disappears only through fission in ^{239}Pu. (b) According to Table 21.2 each t U from a PWR contains 8.69 kg Pu; why is your result much lower?

(a)

$\phi := 4.4\cdot 10^{13}\cdot cm^{-2}\cdot sec^{-1}$ $\quad\sigma_{c238} := 1.5\cdot 10^{-28}\cdot m^2$ $\quad\sigma_{f239} := 1048.7\cdot 10^{-28}\cdot m^2$

$p_{fuel} := \dfrac{1912\cdot 10^6}{86600\cdot 10^3}\cdot watt\cdot kg^{-1}$ $\quad Q_{spent} := \dfrac{27500\cdot 10^6\cdot 24\cdot 60\cdot 60}{1000}\cdot joule\cdot kg^{-1}$

$t_{irr} := \dfrac{Q_{spent}}{p_{fuel}}$ $\quad t_{irr} = 1.076\cdot 10^{11}\cdot \mathrm{sec}$ $\quad N_A := 6.022137\cdot 10^{23}\cdot mole^{-1}$

$m_U := 1000\cdot kg$ $\quad M_U := 238.03\cdot gm\cdot mole^{-1}$ $\quad M_{Pu} := 239\cdot gm\cdot mole^{-1}$

$x_{235} := 2.6\cdot\%$ $\quad x_{238} := 1 - x_{235}$ $\quad N_{238} := \dfrac{m_U}{M_U}\cdot N_A\cdot x_{238}$

$$N_{239} := \frac{\sigma_{c238}\cdot N_{238}}{\sigma_{f239}}\cdot\left(1 - exp\left(-\phi\cdot\sigma_{f239}\cdot t_{irr}\right)\right) \qquad N_{239} = 3.525\cdot 10^{24}$$

$$m_{239} := \frac{N_{239}}{N_A}\cdot M_{Pu} \qquad m_{239} = 1.40\cdot \mathrm{kg}$$

(b) 1. Effective x-sections differ, 2. Self screening in U neglected, 3. Capture to little fissionable ^{240}Pu was neglected. 4. Self-screening in ^{239}Pu also neglected, gives less fission.