

(19.6) The world's first water boiler reactor (LOPO, Los Alamos, 1944) was a homogeneous solution of enriched uranium sulfate as follows: 580 g ^{235}U , 3378 g ^{238}U , 534 g S, 14068 g O, and 1573 g H. From these values, and Tables 19.2 and 19.3, calculate η and f ; neglect S. With $p = 0.957$, what will k_{infinity} be?

$$\text{barn} := 10^{-28} \cdot \text{m}^2$$

$$N_A := 6.022137 \cdot 10^{23} \cdot \text{mole}^{-1}$$

$$\sigma_{j235} := 98.6 \cdot \text{barn}$$

$$\sigma_{j238} := 2.70 \cdot \text{barn}$$

$$\sigma_{\text{aH}_2\text{O}} := 0.66 \cdot \text{barn}$$

$$\sigma_{f235} := 582.2 \cdot \text{barn}$$

$$\sigma_{f238} := 0.5 \cdot 10^{-3} \cdot \text{barn}$$

$$\nu_{235} := 2.418$$

$$M_{235} := 235 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$M_{238} := 238 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$M_{\text{O}} := 16.00 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$M_{\text{H}} := 1.008 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$m_{235} := 580 \cdot \text{gm}$$

$$m_{238} := 3378 \cdot \text{gm}$$

$$m_{\text{O}} := 14068 \cdot \text{gm}$$

$$m_{\text{H}} := 1573 \cdot \text{gm}$$

$$m_{\text{S}} := 534 \cdot \text{gm}$$

$$N_{235} := \frac{m_{235}}{M_{235}} \cdot N_A$$

$$N_{238} := \frac{m_{238}}{M_{238}} \cdot N_A$$

$$x_{235} := \frac{N_{235}}{N_{235} + N_{238}}$$

$$x_{238} := 1 - x_{235}$$

$$\alpha := \frac{\sigma_{j235} \cdot x_{235} + \sigma_{j238} \cdot x_{238}}{\sigma_{f235} \cdot x_{235}}$$

$$\alpha = 0.196$$

$$\eta := \frac{\nu_{235}}{1 + \alpha}$$

$$\eta = 2.022$$

$$s_{\text{afuel}} := N_{235} (\sigma_{j235} + \sigma_{f235}) + N_{238} \sigma_{j238}$$

$$N_{\text{H}_2\text{O}} := \frac{m_{\text{O}} + m_{\text{H}}}{2 \cdot M_{\text{H}} + M_{\text{O}}} \cdot N_A$$

$$s_{\text{aH}_2\text{O}} := \sigma_{\text{aH}_2\text{O}} \cdot N_{\text{H}_2\text{O}}$$

$$f := \frac{s_{\text{afuel}}}{s_{\text{afuel}} + s_{\text{aH}_2\text{O}}}$$

$$f = 0.75$$

$$p := 0.957$$

$$\varepsilon := 1$$

$\varepsilon = 1$ for any homogeneous and dilute reactor

$$k_{\text{infinity}} := \eta \cdot \varepsilon \cdot p \cdot f$$

$$k_{\text{infinity}} = 1.451$$