(18.5) Ten mg ^{238}U has been collected in the kidneys. Considering the biological half-life of uranium and assuming only one α-emission in ^{238}U decay, calculate the dose (in Sv) received by the organs if the uranium is evenly distributed. The weight of a kidney is 150 g.

Constants, data, and units:

$N_A := 6.022137 \cdot 10^{23} \cdot mole^{-1}$ $M_U := 238 \cdot gm \cdot mole^{-1}$ $MeV := 1.6021773 \cdot 10^{-13} \cdot joule$

$Gy := joule \cdot kg^{-1}$ $Sv := joule \cdot kg^{-1}$ $mSv := 0.001 \cdot Sv$

$w_{R\alpha} := 20$ $t_{biol} := 15 \cdot day$ $E_\alpha := 4.198 \cdot MeV$

Data from the text:

$m_{kidney} := 2 \cdot 150 \cdot gm$ 2 kidneys $m_U := 10 \cdot mg$

Calculations:

$\lambda_{biol} := \frac{ln(2)}{t_{biol}}$ $t_{mean} := \frac{1}{\lambda_{biol}}$

$t_{half} := 4.468 \cdot 10^9 \cdot yr$ $\lambda_{phys} := \frac{ln(2)}{t_{half}}$

$N_{0U} := \frac{m_U}{M_U} \cdot N_A$ $R_{0U} := \lambda_{phys} \cdot N_{0U}$ $R_{0U} = 124.392 \cdot sec^{-1}$

$D_{kidney} := \frac{t_{mean} \cdot R_{0U} \cdot E_\alpha}{m_{kidney}}$ $D_{kidney} = 5.214 \cdot 10^{-4} \cdot Gy$

$H_{kidney} := D_{kidney} \cdot w_{R\alpha}$ $H_{kidney} = 10 \cdot mSv$