63. (a) The mass of a ^{238}U atom is $(238\,\mathrm{u})(1.661 \times 10^{-24}\,\mathrm{g/u}) = 3.95 \times 10^{-22}\,\mathrm{g}$, so the number of uranium atoms in the rock is $N_U = (4.20 \times 10^{-3}\,\mathrm{g})/(3.95 \times 10^{-22}\,\mathrm{g}) = 1.06 \times 10^{19}$. The mass of a ^{206}Pb atom is $(206\,\mathrm{u})(1.661 \times 10^{-24}\,\mathrm{g}) = 3.42 \times 10^{-22}\,\mathrm{g}$, so the number of lead atoms in the rock is $N_{\mathrm{Pb}} = (2.135 \times 10^{-3}\,\mathrm{g})/(3.42 \times 10^{-22}\,\mathrm{g}) = 6.24 \times 10^{18}$.

(b) If no lead was lost, there was originally one uranium atom for each lead atom formed by decay, in addition to the uranium atoms that did not yet decay. Thus, the original number of uranium atoms was $N_{U0} = N_U + N_{\mathrm{Pb}} = 1.06 \times 10^{19} + 6.24 \times 10^{18} = 1.68 \times 10^{19}$.

(c) We use

$$N_U = N_{U0}\, e^{-\lambda t}$$

where λ is the disintegration constant for the decay. It is related to the half-life $T_{1/2}$ by $\lambda = (\ln 2)/T_{1/2}$. Thus

$$t = -\frac{1}{\lambda} \ln\left(\frac{N_U}{N_{U0}}\right) = -\frac{T_{1/2}}{\ln 2} \ln\left(\frac{N_U}{N_{U0}}\right) = -\frac{4.47 \times 10^9\,\mathrm{y}}{\ln 2} \ln\left(\frac{1.06 \times 10^{19}}{1.68 \times 10^{19}}\right) = 2.97 \times 10^9\ \mathrm{y}\ .$$