(5.6) A mineral was found to contain 39.1 g K and $87.2 \cdot 10^{-6}$ liter Ar at NTP. How old is the mineral?

As usual we define some constants first:

$$R := 0.08206 \cdot liter \cdot atm \cdot mole^{-1} \cdot K^{-1} \qquad N_A := 6.022 \cdot 10^{23} \cdot mole^{-1}$$

$$Mw_K := 39.10 \cdot \frac{gm}{mole} \qquad Mw_{Ar} := 40 \cdot \frac{gm}{mole}$$

Then use the half-life from Table 5.2 to compute the decay constant, λ, as follows:

$$t_{half} := 1.28 \cdot 10^9 \cdot yr \qquad \lambda := \frac{ln(2)}{t_{half}}$$

NTP corresponds to: $T := 273.15 \cdot K$ $\quad p := 1 \cdot atm$ $\quad V_{Ar} := 87.2 \cdot 10^{-6} \cdot liter$

From the known amount of potassium and the atomic fraction of ^{40}K we can calculate the total number of ^{40}K atoms, N_{K40}:

$$m_K := 39.1 \cdot gm \qquad N_K := \frac{m_K}{Mw_K} \cdot N_A \qquad x_{40K} := 0.0117 \cdot \% \qquad N_{K40} := N_K \cdot x_{40K}$$

Then we can calculate the number of argon atoms, N_{Ar}, by using the general gas-law:

$$n_{Ar} := \frac{V_{Ar} \cdot p}{R \cdot T} \qquad N_{Ar} := n_{Ar} \cdot N_A$$

However, as argon was formed by decay of ^{40}K we can assume that as many ^{40}K atoms have decayed as the number of argon atoms found:

$$dN_K := \frac{N_{Ar}}{0.1067}$$

Now it is possible to calculate the time (age) from eqn. (4.41a):

$$t := \frac{ln\left(\frac{dN_K}{N_{K40}} + 1\right)}{\lambda} \qquad t = 1.581 \cdot 10^{16} \cdot sec \qquad \text{or} \qquad t = 5.01 \cdot 10^8 \cdot yr$$