

(13.9) 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:

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

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

Then use the half-life from Table 13.3 to compute the decay constant,  $\lambda$ , as follows:

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

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

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

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

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

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

However, as argon was formed by decay of  $^{40}\text{K}$  we can assume that as many  $^{40}\text{K}$  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. (5.57):

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