

(4.14) In the ion source of a mass spectrograph, UF_6 vapor is introduced which partly becomes ionized to UF_5^+ . The ionic currents were measured at mass positions 333, 330, and 329. The ion current ratios were $i_{333}/i_{330} = 139$, and $i_{330}/i_{329} = 141.5$. What is the half-life of ^{234}U if that of ^{238}U is $4.5 \cdot 10^9$ y? Radioactive equilibrium is assumed to exist in the UF_6 .

First we define the atomic weights

$$M_F := 19 \cdot \text{gm} \cdot \text{mole}^{-1} \quad M_{U234} := 234 \cdot \text{gm} \cdot \text{mole}^{-1} \quad M_{U238} := 238 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$M_{U234F5} := M_{U234} + 5 \cdot M_F \quad M_{U234F5} = 0.329 \cdot \text{kg} \cdot \text{mole}^{-1}$$

$$M_{U238F5} := M_{U238} + 5 \cdot M_F \quad M_{U238F5} = 0.333 \cdot \text{kg} \cdot \text{mole}^{-1}$$

The measured ionic currents are:

$$I_{333} := 139 \quad I_{329} := 141.5$$

$$\text{Ratio} := \frac{1}{I_{333} I_{329}} \quad \text{Ratio} = 5.084 \cdot 10^{-5}$$

Then apply the condition for radioactive equilibrium: $N_m/t_{1/2m} = N_d/t_{1/2d}$

$$t_{238} := 4.5 \cdot 10^9 \cdot \text{yr} \quad \text{Known half-life of the mother}$$

$$t_{234} := t_{238} \cdot \text{Ratio} \quad t_{234} = 7.22 \cdot 10^{12} \cdot \text{sec} \quad \text{or} \quad t_{234} = 2.3 \cdot 10^5 \cdot \text{yr}$$