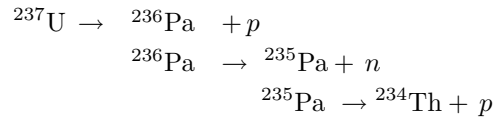


48. (a) The nuclear reaction is written as $^{238}\text{U} \rightarrow ^{234}\text{Th} + ^4\text{He}$. The energy released is

$$\begin{aligned}\Delta E_1 &= (m_{\text{U}} - m_{\text{He}} - m_{\text{Th}})c^2 \\ &= (238.05079 \text{ u} - 4.00260 \text{ u} - 234.04363 \text{ u})(931.5 \text{ MeV/u}) \\ &= 4.25 \text{ MeV} .\end{aligned}$$

(b) The reaction series consists of $^{238}\text{U} \rightarrow ^{237}\text{U} + n$, followed by



The net energy released is then

$$\begin{aligned}\Delta E_2 &= (m_{^{238}\text{U}} - m_{^{237}\text{U}} - m_n)c^2 + (m_{^{237}\text{U}} - m_{^{236}\text{Pa}} - m_p)c^2 \\ &\quad + (m_{^{236}\text{Pa}} - m_{^{235}\text{Pa}} - m_n)c^2 + (m_{^{235}\text{Pa}} - m_{^{234}\text{Th}} - m_p)c^2 \\ &= (m_{^{238}\text{U}} - 2m_n - 2m_p - m_{^{234}\text{Th}})c^2 \\ &= [238.05079 \text{ u} - 2(1.00867 \text{ u}) - 2(1.00783 \text{ u}) - 234.04363 \text{ u}](931.5 \text{ MeV/u}) \\ &= -24.1 \text{ MeV} .\end{aligned}$$

(c) This leads us to conclude that the binding energy of the α particle is

$$|(2m_n + 2m_p - m_{\text{He}})c^2| = |-24.1 \text{ MeV} - 4.25 \text{ MeV}| = 28.3 \text{ MeV} .$$