49. Energy and momentum are conserved. We assume the residual thorium nucleus is in its ground state. Let K_α be the kinetic energy of the alpha particle and $K_{\rm Th}$ be the kinetic energy of the thorium nucleus. Then, $Q = K_\alpha + K_{\rm Th}$. We assume the uranium nucleus is initially at rest. Then, conservation of momentum yields $0 = p_\alpha + p_{\rm Th}$, where p_α is the momentum of the alpha particle and $p_{\rm Th}$ is the momentum of the thorium nucleus. Both particles travel slowly enough that the classical relationship between momentum and energy can be used. Thus $K_{\rm Th} = p_{\rm Th}^2/2m_{\rm Th}$, where $m_{\rm Th}$ is the mass of the thorium nucleus. We substitute $p_{\rm Th} = -p_\alpha$ and use $K_\alpha = p_\alpha^2/2m_\alpha$ to obtain $K_{\rm Th} = (m_\alpha/m_{\rm Th})K_\alpha$. Consequently,

$$Q = K_\alpha + \frac{m_\alpha}{m_{\rm Th}} K_\alpha = \left(1 + \frac{m_\alpha}{m_{\rm Th}}\right) K_\alpha = \left(1 + \frac{4.00\,{\rm u}}{234\,{\rm u}}\right)(4.196\,{\rm MeV}) = 4.27\ {\rm MeV}\ .$$