82. (a) At the smallest center-to-center separation $r_{\min}$ the initial kinetic energy K_i of the proton is entirely converted to the electric potential energy between the proton and the nucleus. Thus,

$$K_i = \frac{1}{4\pi\varepsilon_0}\frac{eq_{\text{lead}}}{r_{\min}} = \frac{82e^2}{4\pi\varepsilon_0 r_{\min}} \ .$$

In solving for $r_{\min}$ using the eV unit, we note that a factor of e cancels in the middle line:

$$\begin{aligned} r_{\min} &= \frac{82e^2}{4\pi\varepsilon_0 K_i} = k\frac{82e^2}{4.80\times10^6\ e\text{V}} \\ &= \left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\frac{82(1.6\times10^{-19}\ \text{C})}{4.80\times10^6\ \text{V}} \\ &= 2.5\times10^{-14}\ \text{m} = 25\ \text{fm} \ . \end{aligned}$$

It is worth recalling that a volt is a Newton·meter/Coulomb, in making sense of the above manipulations.

(b) An alpha particle has 2 protons (as well as 2 neutrons). Therefore, using $r'_{\min}$ for the new separation, we find

$$K_i = \frac{1}{4\pi\varepsilon_0}\frac{q_\alpha q_{\text{lead}}}{r'_{\min}} = 2\left(\frac{82e^2}{4\pi\varepsilon_0 r'_{\min}}\right) = \frac{82e^2}{4\pi\varepsilon_0 r_{\min}}$$

which leads to $r'_{\min} = 2r_{\min} = 50\,\text{fm}$.