6. From Equation 6.19,

$$K = \frac{e^2}{4\pi\varepsilon_0} \frac{Zz}{d} = \frac{(1.440\,\mathrm{MeV\cdot fm})(2)(79)}{7.0\,\mathrm{fm}} = 33\,\mathrm{MeV}$$

7. $\quad d = \dfrac{e^2}{4\pi\varepsilon_0} \dfrac{Zz}{K} = \dfrac{(1.440\,\mathrm{MeV\cdot fm})(2)(29)}{7.4\,\mathrm{MeV}} = 11.3\,\mathrm{fm}$

14. From the Rutherford scattering formula (Eq. 6.14) the only difference between the two positions is the term depending on the angle – all other parameters are the same for the two experiments. The expected ratio between the two counting rates is then

$$\frac{N(150°)}{N(10°)} = \frac{\sin^{-4}(150°/2)}{\sin^{-4}(10°/2)} = 6.63 \times 10^{-5}$$

so the rate at $150°$ would be $(11.3/s)(6.63 \times 10^{-5}) = 7.49 \times 10^{-4}$ /s.

48. The Rutherford formula will fail when the distance of closest approach is less than the combined radii of the alpha particle and aluminum nucleus. Rewriting Eq. 6.19 for the distance of closest approach in a head-on collision,

$$K = \frac{e^2}{4\pi\varepsilon_0} \frac{zZ}{d} = (1.44 \text{ MeV} \cdot \text{fm}) \frac{(2)(13)}{1.9 \text{ fm} + 3.6 \text{ fm}} = 6.8 \text{ MeV}$$

Alpha particles of energy greater than 6.8 MeV will penetrate the aluminum nucleus can cause a breakdown in the Rutherford scattering formula. Such energies from radioactive decay were available in Rutherford's time.