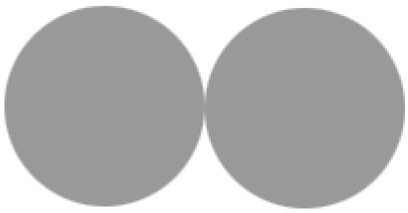
**337.**

**Problem 30.5 (RHK)**

*In the figure an idealised representation of* $^{238}U$ *nucleus* $\left(Z=92\right)$ *on the verge of fission is shown. We have to calculate* (a) *the repulsive force acting on each fragment and* (b) *the mutual electric potential energy of the two fragments. We may assume that the fragments are equal in size and charge, spherical, and just touching. The radius of the initially spherical* $^{238}U$ *is* 8.0 fm. *We will assume that the material out of which nuclei are made has a constant density.*



**Solution:**

We will use the approximation that the material out of which the $^{238}U$ nucleus and its two equal spherical parts are made out of has a constant density. The radius of the $^{238}U$ nucleus is

$R = 8.0 \text{ fm} = 8.0 \times 10^{-15} \text{ m}.$

Let the radius of the two equal spherical parts in which the $^{238}U$ nucleus splits be $a$. Under our assumption

$$2 \times \left( \frac{4\pi}{3} a^3 \rho \right) = \left( \frac{4\pi}{3} R^3 \rho \right),$$

$$\therefore \ a = \frac{R}{2^{\frac{1}{3}}} = \frac{8.0 \times 10^{-15} \text{ m}}{2^{\frac{1}{3}}} = 6.349 \times 10^{-15} \text{ m}.$$

(a)

Each spherical fragment of $^{238}U$ nucleus will have a charge equal to $+46e$. Separation of the two spherical fragments from each other in the configuration shown in the figure is $2a$. Therefore, the repulsive force acting on each fragment is

$$F = \frac{1}{4\pi\varepsilon_0} \times \frac{(46e)^2}{(2a)^2} = \frac{8.99 \times 10^9 \times \left(46 \times 1.6 \times 10^{-19}\right)^2}{\left(2 \times 6.439 \times 10^{-15}\right)^2} \text{ N}$$

$$= 3.02 \times 10^3 \text{ N} = 3.02 \text{ kN}.$$

(b)

The mutual electric potential energy of the two fragments will be

$$U=\frac{1}{4\pi\varepsilon_0}\times\frac{(46e)^2}{2a}=\frac{8.99\times10^9\times\left(46\times1.6\times10^{-19}\right)^2}{2\times6.349\times10^{-15}}\ \text{J}$$

$$=3.835\times10^{-11}\ \text{J}=\frac{3.835\times10^{-11}}{1.6\times10^{-13}}\ \text{MeV}$$

$$=239.7\ \text{MeV}.$$