

4.1 A simple problem in electrostatics! Show that the potential energy due to electrostatic forces of a uniformly charged sphere of total charge Q and radius R is $3Q^2/(20\pi\epsilon_0 R)$.

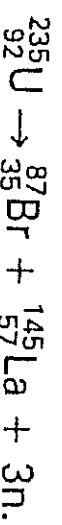
4.2 The Coulomb term in the semi-empirical mass formula is

$$a_c Z^2/A^{1/3}.$$

Using the result of Problem 4.1, calculate the value of a_c in MeV/ c^2 . Assume that the nuclear radius is given by $R = 1.24 \times A^{1/3}$ fm.

Using the values of a_v , a_s , and a_A given in Table 4.1 and the fact that the binding energy of ${}^{181}_{73}\text{Ta}$ is 1454 MeV, check your value of a_c . Comment on any discrepancy you may find.

The nucleus ${}^{235}_{92}\text{U}$ can undergo spontaneous fission (see Chapter 6): one of the many fission channels is



Estimate the energy released in this channel.

5.1 Explain the terms in the semi-empirical atomic mass formula:

$$\mathcal{M}(Z,A) = ZM_p + NM_n - a_v A + a_s A^{2/3} + a_c Z^2/A^{1/3} + a_a (A - 2Z)^2/A \pm a_p/A^{1/2}.$$

Show for large A and Z that the energy released when a nucleus (Z,A) emits an α -particle is given by

$$Q_\alpha = -4a_v + 8a_s/3A^{1/3} + 4a_c Z(1 - Z/3A)/A^{1/3} - 4a_a (N - Z)^2/A^2 + B(2,4).$$

where $B(2,4)$ is the binding energy of the α -particle, 28.30 MeV.

The only naturally occurring isotopes of silver and gold are $^{107}_{47}\text{Ag}$ and $^{197}_{79}\text{Au}$. Discuss the stability of these nuclei in the light of the expression for Q_α . Use the values for the coefficients a given in Table 4.1.