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 $3Q^2/(20\pi\varepsilon_0 R)$.

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 $^{181}_{73}$Ta is 1454 MeV, check your value of a_C. Comment on any discrepancy you may find.

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

$$^{235}_{92}\mathrm{U} \rightarrow {}^{87}_{35}\mathrm{Br} + {}^{145}_{57}\mathrm{La} + 3\mathrm{n}.$$

Estimate the energy released in this channel.

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

$$\mathcal{M}(Z,A) = ZM_H + NM_n - a_v A + a_S A^{2/3} + a_C Z^2/A^{1/3} + a_A (A-2Z)^2/A \pm a_p/A^{1/2}.$$

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 $^{107}_{47}$Ag and $^{197}_{79}$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.