Chemistry 485

Spring, 2o1o — Problem Set #9
Distributed: Wed., 14 Apr. 2o1o — Due: Mon., 19 Apr. 2o1o
(10 points)

The energy lost by a beam of charged particles that pass through a target generally goes into heating the target. Use the Bethe-Bloch equation for the rate of energy loss to answer the following questions.

1. In preparation for the next step, calculate the values of the relativistic parameters β and γ for a $^{48}Ca^{20+}$ beam with an energy of 480 MeV, or E/A = 10.0 MeV.

2. Calculate the rate of energy loss, dE/dx, in MeV/cm of a $^{48}Ca^{20+}$ beam with an energy of 480 MeV in a beryllium metal foil. The textbook gives an expression for the average ionization potential: $I = (7 + 12 * Z)eV, for Z < 13$.

3. Calculate the amount of energy, ΔE, in MeV deposited by a single particle of a $^{48}Ca^{20+}$ at an energy of 480 MeV in a beryllium metal foil that is 10 μm thick.

4. Calculate the rate of energy deposited in this same 10 μm foil, $\Delta E/\Delta t$, by a beam of these calcium ions flowing with an electrical current of 1.00 nA.

5. What is the power in Watts delivered to the metal from the energy deposited by this beam at a 1.00 nA current?

6. What is the rate of heating of the foil (degrees/sec) by this beam current if the heat capacity of beryllium is 1.82 J/g/K? The foil has an area of 5 cm by 2.5 cm.