**Due: Thursday, 02/24**

**10. This is an optional problem, i.e., it is not necessary to solve it. However, those who do will get a nice credit.**

The lowest-energy configuration of atomic praseodymium (Pr) is \([\text{Xe}]4f^36s^2\).

a). Find all possible terms of this configuration.
b). Which of these terms is the lowest-energy term?
c). What is the total angular momentum \(J\) of the lowest energy level in this term?

*Hint:* it may be easier to write a computer code for part (a) rather than to do it by hand.

**11.** For hydrogen-like ions with nuclear charge \(Z\), find the scaling with \(Z\) of:

a) Fine structure energy splitting

b) Hyperfine structure energy splitting

c) Compare these results with \(Z\)-scaling for neutral atoms discussed in class.

**12.** If an electric field \(\varepsilon\) is applied to an atom in the \(z\)-direction, the potential energy of an electron at \(z \rightarrow -\infty\) assumes infinitely large negative values. An electron can tunnel through the resulting potential barrier; this process is called *field ionization*. The probability per unit time of field ionization for hydrogen in the ground state is given e.g. in Landau and Lifshits, *Quantum Mechanics*, section 77:

\[
w = \frac{4m^3|e|^9}{\varepsilon \cdot h^7} \exp\left(-\frac{2m^3|e|^5}{3\varepsilon \cdot h^4}\right), \quad m \text{ is the electron mass.}
\]

Starting from this expression, write down field ionization probability for a hydrogenic ion with nuclear charge \(Z\). Pick any values of \(\varepsilon\) and \(Z\) and calculate the numerical value of \(w\).