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 $[Xe]4f^3 6s^2$.

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 ε is applied to an atom in the z-direction, the potential energy of an electron at $z \to -\infty$ 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:

$$w = \frac{4m^3|e|^9}{\varepsilon \cdot \hbar^7} \exp\left(-\frac{2m^2|e|^5}{3\varepsilon \cdot \hbar^4}\right)$$, *m* 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 ε and Z and calculate the numerical value of *w*.