1. (25) The *proper* lifetime (*lifetime in its rest frame*) of a certain particle is 100.0 ns. An observer in a laboratory sees it moving at $v = 0.960\ c$.

A. What is the particle's lifetime in the lab?
B. How far does the particle travel in the lab during 100 ns of lab time?
C. What is the distance the particle travels in the lab during 100 ns of lab time according to an observer moving with the particle?

2. (20) The cutoff wavelength for the photoelectric effect in a certain metal is 254 nm.

A. What is the work function for that metal?
B. Will electrons be emitted from the metal for $\lambda > 254$ nm or $\lambda < 254$ nm?

3. (15) What are the most important differences between light emitted from a source based on atomic transitions (*such as a gas discharge, fluorescent or mercury tube*) compared to light from a thermal source (*an incandescent light bulb*)?

4. (20) To what voltage must we accelerate electrons in an electron microscope if we wish to resolve each of the following?

A. A virus of diameter 12 nm.
B. An atom of diameter 0.12 nm?
C. A proton of diameter 1.2 fm?

5. (30) Consider a quantum mechanical one dimensional step potential, with $U = 0$ for negative x and $U = +U_o$ for positive x.

A. Including 4 undetermined constants, write down the general form of the wave functions for the two regions $x < 0$ and and $x > 0$ with the condition that the total energy E lies in the range $0 < E < U_o$.
B. Which of the coefficients in your expressions of part A must be set to zero? Why?
C. Describe in words how you should proceed to solve for the detailed form of the wavefunctions and energies. Do not attempt to actually carry out this procedure.
D. Sketch a possible wavefunction.

6. (20) The following questions each apply to a quantum mechanical hydrogen atom.

A. What are the possible values of l for $n = 6$?

B. What are the possible values of m_l for $l = 6$?

C. What is the smallest possible value of n for which l can be 4?

D. What is the smallest possible l that can have a z component of $4\hbar$?

7. (20) Tritium has a half-life of 12.3 years.

A. What is tritium?

B. What is a half-life?

C. What fraction of the tritium atoms remain in a sample after 50.0 years?

8. (50) Respond to each of the following questions with a few sentences.

A. What is a *Fermi* energy?

B. What fundamental material properties distinguish a semiconductor from a conductor?

C. Which of the elements are formed in stars?

D. Compare the properties of the *strong* force or interaction to those of the *electroweak* force or interaction.

E. What are the basic premises of the *Standard Model*?