1. A hydrogen atom in its ground state absorbs light at 93.8 nm to form an excited state. From this excited state it emits light with a wavelength of 1090 nm.

   a. Identify the quantum numbers for the initial and final states when the light at 93.8 nm is absorbed. Show how you reached your answer.

   b. Identify the quantum numbers for the initial and final states when light at 1090 nm is emitted.

   c. Sketch an energy level diagram for the H atom, and show the two transitions using arrows.

   d. How much energy (in Joules) would be required to ionize the hydrogen atom from the state formed after emission of the photon with a wavelength of 1090 nm?
2. X-ray diffraction is a common technique used by chemists to determine the locations of atoms in compounds and biological macromolecules that form regularly ordered solids. Resolutions of 1–2 Å are common in x-ray diffraction measurements. Neutron diffraction provides complementary information with comparable resolution to x-ray diffraction. For example, x-ray diffraction is best for locating heavy nuclei, and it is generally not possible to locate hydrogen atoms in x-ray diffraction measurements. In contrast, hydrogen and deuterium atoms scatter neutrons very well. Furthermore, the scattering of neutrons by hydrogen nuclei differs from the scattering by deuterium nuclei making it possible to distinguish between these two types of nuclei in scattering experiments.

a. What is the kinetic energy of an electron with a deBroglie wavelength of 1 Å?

b. What kinetic energy must a neutron have in order to have a deBroglie wavelength of 1 Å?

c. What is the uncertainty in locating the neutron if the kinetic energies can range from zero to the value determined in part b?

d. What is the uncertainty in locating this neutron assuming an uncertainty in its kinetic energy that is 10% of the value determined in part b?

e. What impact does constraining the range of kinetic energies for a beam of neutrons have on our ability to locate them?