Problem 1

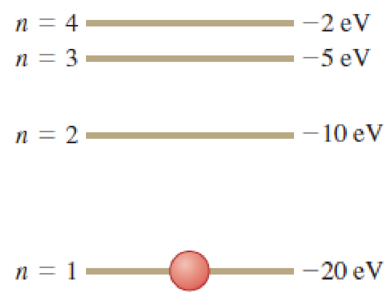
How fast would an electron have to move so that its de Broglie wavelength is 1.00 mm?

Problem 2

(a) What accelerating potential is needed to produce electrons of wavelength 5.00 nm?
(b) What would be the energy of photons having the same wavelength as these electrons?
(c) What would be the wavelength of photons having the same energy as the electrons in part (a)?

Problem 3

The energy-level scheme for the hypothetical one-electron element Searsium is shown in the figure. The potential energy is taken to be zero for an electron at an infinite distance from the nucleus.



(a) How much energy (in electron volts) does it take to ionize an electron from the ground level?
(b) An 18-eV photon is absorbed by a Searsium atom in its ground level. As the atom returns to its ground level, what possible energies can the emitted photons have? Assume that there can be transitions between all pairs of levels.
(c) What will happen if a photon with an energy of 8 eV strikes a Searsium atom in its ground level? Explain your reasoning.
(d) Photons emitted in the Searsium transitions $n = 3 \rightarrow n = 2$ and $n = 3 \rightarrow n = 1$ will eject photoelectrons from an unknown metal, but the photon emitted from the transition $n = 4 \rightarrow n = 3$ will not. What are the limits (maximum and minimum possible values) of the work function of the metal?

Problem 4

Use Balmer's formula to calculate (a) the wavelength, (b) the frequency, and (c) the photon energy for the H_γ line of the Balmer series for hydrogen.

Problem 5

A large number of neon atoms are in thermal equilibrium. What is the ratio of the number of atoms in a 5*s* state to the number in a 3*p* state at (a) 300 K; (b) 600 K; (c) 1200 K? The energies of these states, relative to the ground state, are E_{5s} = 20.66 eV and E_{3p} = 18.70 eV. (d) At any of these temperatures, explain why the rate at which a neon gas will spontaneously emit 632.8 nm radiation is quite low.

Problem 6

Determine λ_m, the wavelength at the peak of the Planck distribution, and the corresponding frequency f, at the temperatures (a) 3.00 K, (b) 300 K, and (c) 3000 K.

Problem 7

The shortest visible wavelength is about 400 nm. What is the temperature of an ideal radiator whose spectral emittance peaks at this wavelength?

Problem 8

The negative muon has a charge equal to that of an electron but a mass that is 207 times as great. Consider a hydrogen-like atom consisting of a proton and a muon. (a) What is the reduced mass of the atom? (b) What is the ground-level energy (in electron volts)? (c) What is the wavelength of the radiation emitted in the transition from the $n = 2$ level to the $n = 1$ level?

Problem 9

An atom in a metastable state has a lifetime of 5.2 ms. What is the uncertainty in energy of the metastable state?

Problem 10

The figure below shows the energy levels of the sodium atom. The two lowest excited levels are shown in columns labeled $^2P_{3/2}$ and $^2P_{1/2}$. Find the ratio of the number of atoms in a $^2P_{3/2}$ state to the number in a $^2P_{1/2}$ state for a sodium gas in thermal equilibrium at 500 K.