Problem Set #2

1. Sodium has a work function of 4.41×10^{-19} J. When it is illuminated by light of a particular frequency, electrons emerge with velocity $v = 8.79 \times 10^5$ m·s^{-1}.

   (a) What is the momentum, kinetic energy, and wavelength of each emerging photoelecton?

   (b) What is the frequency of the incident light?

   (c) It is found that a burst of light causes 1.58×10^{21} electrons to emerge from the sodium. What is the total energy in that burst of light?

   (d) Suppose light with a frequency of 6.52×10^{13} Hz is incident on the sodium. How many photoelectrons will be produced by an irradiation of 5000.0 J?

2. A young professor has volunteered to go to the local high school and teach the AP chemistry students about the photoelectric effect. She believes a live demonstration will really get the students excited and so acquires a large block of aluminum ($\Phi = 4.08$ eV) for her demonstration.

   (a) The professor needs a light source to irradiate the aluminum. Calculate the maximum or minimum wavelength in nm of the radiation necessary to liberate photoelectrons from her aluminum. Indicate if it is a minimum or maximum.

   (b) The professor wants to make sure that the demonstration goes well and that a lot of electrons are ejected for dramatic effect. What should the professor make sure is true about her radiation source if she wants to increase the number of ejected photoelectrons?

3. Albertín Aroldis Chapman de la Cruz holds the record for the fastest recorded pitch speed in MLB history (105 mph).

   (a) Calculate the wavelength of the ball at that velocity assuming the ball is 6.7 cm in diameter and has a mass of 145.7 ounces.

   (b) Would a tennis ball (mass = 57 g) with the same wavelength have more or less velocity than the baseball? Why?

   (c) At what velocity would a tennis ball have the same wavelength?

4. The following questions concern the spectral series for atomic hydrogen.

   (a) Use the Rydberg formula for atomic hydrogen to calculate the wavelength of the photon ejected for the transition from $n = 5$ to $n = 2$.

   (b) What is the name given to the spectroscopic series to which this transition belongs?

   (c) Use Table 1.1 (page 4 in the 5^{th} edition, page 5 in the 4^{th} edition) to determine the region of the spectrum in which the transition takes place. If the change takes place in the visible region of the spectrum, what color will be emitted?

5. The following questions concern the electron transitions of atomic hydrogen.

   (a) What is the highest energy photon that can be absorbed by an electron in the second excited state of hydrogen atom without causing ionization?

   (b) What is the wavelength of this radiation?

(c) To what region of the electromagnetic spectrum does this photon belong to?

6. In the spectrum of atomic hydrogen, there is a red line known as the H-alpha line that is observed at 656.3 nm. Determine the beginning and ending energy levels of the emitting electron that leads to this spectral line.

7. Calculate the frequency (in Hz) of the photon necessary to excite a helium ion, He^{+}, from the 1s to 4d orbital.

8. Consider the Mg^{11+} ion. Calculate the energy (in joules) of the photon emitted when the electron goes from the 4p to the 1s orbital.

9. Name an energy transition in the hydrogen atom that corresponds to the emission of a blue photon. Use 434 nm for the wavelength of the photon.

10. Evaluate the probability of finding an electron in a small region of a hydrogen 1s-orbitals at a distance of $0.65a_o$ from the nucleus relative to finding it in the same small region located at the nucleus.

11. Use the angular wavefunctions of hydrogen-like atoms to show that the electron distribution is spherically symetrical for an atom in which an electron occupies each of the three p-orbitals of a given shell.

12. **(a)** How many values of the quantum number ℓ are possible when $n = 7$?

    (b) How many values of m_ℓ are allowed for an electron in the $6d$-subshell?

    (c) How many values of m_ℓ are allowed for an electron in the $3p$-subshell?

    (d) How many subshells are there in the shell with $n = 4$?

13. What are the principal and orbital angular momentum quantum numbers for each of the following orbitals (a) $6p$; (b) $3d$; (c) $2p$; (d) $5f$?

14. For each of the orbital listed in question 13, give the possible values for the magnetic quantum number.

15. Which of the following subshells cannot exist in an atom: (a) $3d$; (b) $3f$; (c) $5g$; (d) $6i$