Practice Test Questions 3
Light and the Atom

1. State **one** important conclusion deduced from each of the following experimental observations that helped to determine the "modern" atomic theory.

   In other words, why did we study these experiments? Why were they important?

(a) atomic line spectra

(b) photoelectric effect

2.

(a) Describe the photoelectric effect.

(b) What knowledge about the properties of light was gained from the study of the photoelectric effect?

(c) What was the evidence for this knowledge?

3. Briefly explain why the observation of atomic line spectra disproved Rutherford's model of the atom as a dense positively charged nucleus surrounded by a diffuse cloud of electrons.

4. List the successes and failures of the Bohr atomic theory.

5. Describe the emission spectroscopy experiment. What information do we gain from this experiment?

6. The threshold frequency of an unknown metal was found to be 1.60×10^{15} Hz according to a photoelectric effect experiment.

(a) Calculate the ionization energy of the metal in J.

(b) Calculate the ionization energy of the metal in kJ/mol.

(c) What other frequencies of light could be used to generate a current when shone on this metal?

7. Potassium (K) has an ionization energy of 418.81 kJ/mol.

(a) This is an experimentally measured value. Why can we **not** use the formula:

$$E_n = -R_H \frac{Z^2}{n^2}$$

to calculate the energy of the ground state electron (and therefore the ionization energy) in potassium?

(b) What is the longest wavelength of light that could be used to ionize a sample of potassium atoms? Report your answer in nm.

8.

(a) Light with a wavelength of 65 nm was shone on an unknown metal. A current was generated and the kinetic energy of the electrons was measured to be 2.0×10^{-18} J/electron. Calculate the threshold energy of the metal.

(b) A second experiment was performed. The same unknown metal was exposed to a different beam of light. This beam of light had an energy of 7.33×10^{-15} J, and it did not have the same wavelength as the one in the first experiment. What is the maximum number of electrons that could be ejected from the metal in this second experiment?

9. Excited H atoms give off many different wavelengths of light. One series of wavelengths, called the Pfund series, occurs in the infrared region. It results when an atom drops from a higher energy state to the n = 5 state. Calculate the wavelength and frequency of the lowest energy light of this series.

10. A ruby laser produces light with wavelengths of 694 nm and 628 nm.

(a) Which of these two wavelengths of light has higher energy photons?

(b) Calculate the ionization energy for a hydrogen atom in its ground state *(in J)*.

(c) Could an electron be excited out of a hydrogen atom by irradiating it with a ruby laser *(assuming that these are the only two wavelengths produced by the laser)?* Why or why not?

11. Consider a Li^{2+} cation in the ground state.

(a) Calculate the energy of the lowest energy photon that can be absorbed by a Li^{2+} cation in the ground state.

(b) How would your answer to part (a) change if the phrase “in the ground state” was changed to “in the n=3 state”?

You do <u>not</u> need to include a calculation or provide a numerical value in your answer to part (b) of this question; however, you should <u>briefly</u> explain your answer verbally (and/or pictorially).

12. Using lasers, we can selectively excite atoms to any desired state. In one experiment, a researcher has excited a hydrogen atom to the $n = 8$ state. One of the lines in the emission spectrum from this state has a wavelength of 1940 nm. What is the final value of n for this transition?

13. Consider a He^{+} cation in the ground state.

(a) Calculate the ionization energy of a He^{+} cation in the ground state.

(b) Determine the kinetic energy of the electron excited from a He^{+} ion in its ground state using a photon of frequency 4.776×10^{16} Hz.

(c) Without doing a calculation, would you expect the ionization energy of a hydrogen atom to be more or less than that of a helium cation? Briefly, explain your answer.