CH301 Fall 2009 Worksheet 2

1. Calculate wavelength from the following frequencies.
   a) 625 kHz

   b) 734 MHz

   c) 8.4 E14 Hz

   d) 92 GHz

2. Given the following energies, calculate the frequencies of the photons.
   a) 17 kJ

   b) 564 E-25 J

   c) 98 pJ

   d) 230 J

3. Rank the wavelengths of the photons in question 2 from longest to shortest. Use A, B, C, or D to identify the photon. (Hint: No calculations necessary.)

4. The double slit experiment is a famous demonstration of the wave nature of light: when light of a single frequency is passed through two parallel sits in a barrier, it produces an *interference pattern* on a surface placed on the other side. Draw an example of an interference pattern (as amplitude of light received vs. position). Compare the frequency and phase of the light waves coming from the two slits at the dark spots and at the light spots on the interference pattern.

5. When passed passed through very fine gratings (or even regular crystals), electrons and neutrons form a distinctive pattern of ridges and troughs because of their wave nature. What is this effect called?

6. The description of light as a collection of particles goes back to long before quantum mechanics. Who are two examples of people who proposed such a description before 1800?

7. Classical physics assumed that the intensity of radiation emitted was a function of λ and that at a given temperature as λ increases the intensity of radiation decreased. Therefore, since UV radiation has a short wavelength its intensity distribution should be large. Describe how Plank solved the ultraviolet catastrophe.

8. Before Einstein won the Nobel Prize for discovering the photoelectric effect, classical physics suggested that there is no minima of energy needed to eject electrons from a metal. Explain the principles of the photoelectric effect and how Einstein concluded that light is particle-like.

9. What is the deBroglie wave equation? In your own words, what is its significance?

10. Use the deBroglie equation to calculate the following values.

a) the wavelength of a 70.0 kg person traveling at 6.0 mi/hr.

b) the velocity of an e^- (mass 9.1 E-31 kg) with a wavelength of 450 pm.

c) the mass of a particle traveling at the speed of light with a wavelength of 12 nm.

11. What is the energy difference between the n = 1 and n = 2 energy levels for an electron in a 1 Å box? What is wavelength of a photon with this energy?

12. Could the particle in a box solution be used to approximate atomic energy levels? Why or why not?

13. One of the conditions at which quantum mechanics simplifies to classical mechanics is when the quantum number, n, approaches infinity. What is the probability density for the particle, $\Psi(x)^2$, for the particle in a box in this limit? Does this agree with the classical prediction?

14. Estimate the minimum uncertainty in the position of a stone with mass 1.0 g that is rolling at $\pm$ 1.0 mm·s^{-1}?

15. Estimate the minimum uncertainty in the speed of an electron of mass 9.109 E-31 kg if it is confined in the diameter of an atom (193 pm).

16. Give a brief explanation of each of the following quantum numbers in your own words: n, ℓ, m_ℓ, m_s.

17. True or False? The following set of quantum numbers is acceptable (0,0,0, +1/2). Explain.

18. How many electrons can have the following quantum numbers in an atom: n= 3, l=2?

19. In the simplest way possible, define the Aufbau principle, the Pauli exclusion principle, and Hund's rule.

20. Fix the electron configurations and state which principle(s) is/are being violated.

a) Oxygen

2p	↑↓ ↑↓ ↑↓	2p	___ ___ ___
2s	___	2s	___
1s	↑↓	1s	___

b) Nitrogen

2p	↑↓ ↑ ___	2p	___ ___ ___
2s	↑↓	2s	___
1s	↑↓	1s	___

c) Sulfur

3p	↑↓↑ ↑↓↑ ___	3p	___ ___ ___
3s	↑↓	3s	___
2p	↑↓ ↑↓ ↑↓	2p	___ ___ ___
2s	___	2s	___
1s	↑↓	1s	___