Fall 2009 CH301 Worksheet 1

1. Briefly explain what is meant by "wave-particle duality of light" in your own words.

2. What equation corresponds to the wave nature of light? Diagram the equation as part of your response. Note: diagramming an equation involves labeling each term with its common name, its Greek name if it is a Greek letter, its units (which may have various names) and finally discussing the proportionality of the various terms in the equation.

3. What equation corresponds to the particle nature of light? Diagram the equation as part of your response.

4. Using a little algebra, derive an equation that expresses a photon's energy in terms of its wavelength. What proportionality exists between energy and wavelength?

5. Calculate the frequency of light that corresponds to the following wavelengths in a vacuum.
   a) 700 nm

   b) 45 pm

   c) 12 km

   d) 367 Å

6. How would doubling the frequency of a given photon affect the following values?
   a) E
   b) λ
   c) c
   d) h

7. Calculate the energy of photons of the following types
   a) 350 nm

   b) 423 GHz

   c) 12 cm

   d) 1.15 EHz

8. Order the following types of light from most to least energetic: 10^{6} Hz, 10^{6} m, 10^{-6} m, 10^{22} Hz, 10^{-10} m (Hint: this can be done with zero calculations .)

9. From memory, to the best of your ability, reproduce the electromagnetic spectrum, starting from the most energetic types of electromagnetic radiation:

10. What did Louis de Broglie propose about matter?

11. What equation describes his proposition? Diagram the equation.

12. What is wavelength of a lazy neutron (m = 1.67 E-27 kg) traveling at the speed of light through a vacuum (3.00 E8 $m \cdot s^{-1}$)?

13. In your own words, what is Heisenberg's uncertainty principle?

14. What equation describes Heisenberg's uncertainty principle? Diagram the equation.

15. Classical mechanics made what prediction about the power emitted by black body radiators at short wavelengths? What was observed experimentally and what was this observation called?

16. Define the term "photoelectric effect" in your own words. How did the photoelectric effect impact classical and quantum mechanics?

17. Define the term "degenerate" in your own words in the context of quantum theory.

18. Calculate the energy (E) of a neutron in a 1-dimensional "box" of length (L) 200 nm at principle energy level (n) 2. What is the proprtionality of E to n for the 1-dimensional box?

19. What is the wavelength of an electron in a 100 nm "box" based on the values of the principle quantum number (n) below?

a) n = 3

b) n = 1

c) n = 8

d) n = 5

20. What is the term for a point in a box at which there is zero probability of finding the particle? How many such points are there in a box where n=4.