Physical Chemistry II
Problem Set I

1. Compute the momentum and speed of a neutron with a wavelength of 3mm. A neutron weighs as much as a proton.

2. Compute the momentum of a photon with a wavelength of 350nm. What speed does a hydrogen molecule (H_2) must travel at to have the same momentum?

3. The speed of a proton is measured to be 4.5×10^5 m/s ± 1000 m/s. What is the minimum uncertainty in its position?

4. A 500W green laser (525nm) is turned on for 10 sec. How many photons does it emit? How many mols of photons is this?

5. A laser emits photons with a wavelength of 1064 nm with a power output of 5×10^6 J/s
a. Compute the energy form a 2×10^{-8} s pulse.
b. Compute the energy of one photon from this laser.
c. Compute the number of photons in 10 pulses.

6. The work function for metallic Cesium is 2.14eV. Compute the KE and speed of and electron hit by a photon of wavelength 300nm. What if the wavelength of the photon is 600nm?

7. The work function for metallic Francium is 3.84eV ($1\text{eV} = 1.602677\cdot10^{-19}$ J). Compute the KE and speed of and electron hit by a photon of wavelength 170 pm. What if the wavelength of the photon is 170 μm?

8. Compute the DeBroglie wavelength of an electron accelerated through a potential of 134V. 1V = 1J/C.

9. If the minimum uncertainty in the position of an electron on a straight wire is 150pm compute the minimum uncertainty in its momentum and speed.

10. The Heisenberg uncertainty relation for energy and time is

$$\Delta E \Delta t \geq \frac{\hbar}{2}$$

If the uncertainty in the lifetime of an excited state is 10^{-9}s what is the uncertainty in the state's energy?

11.
a. Explain black body radiation and why it is so important. Sketch a black body curve for T = 100K, 1000K and 10000K. Label the axes.

b. Explain the significance of the double slit experiment for electrons
c. Explain the significance of the photoelectric effect.

12. The Plank distribution is:

$$\rho = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

where k_B is the Boltzmann constant with units of J/K. What are the units of ρ?

13. True/False:
a. A probability density can never be negative
b. The state function can never be negative
c. The state function must always be real
d. The integral of the wave function over "all space" = 1.