NORTH CAROLINA STATE UNIVERSITY
Department of Chemistry Name_____

Physical Chemistry CH437 Problem Set #1
Due Date: August 28, 2015

1. A. Calculate a realistic estimate for the temperature at the surface of Mars using the black body radiation formula. Use the following facts.
   Radius of Mars: 3420 km.
   Distance of Mars from the sun: 230,000,000 km.

Temperature on the surface of Mars = _____.

B. What wavelength is the peak of the black body emission from Mars?

Wavelength = _____ _____

2. A. What is the concentration of a dye molecule that has $\varepsilon(400\ nm) = 105{,}000\ M^{-1}cm^{-1}$ if it has an absorbance of 0.3 at 400 nm in a 0.1 cm pathlength cell?

Concentration = _____.

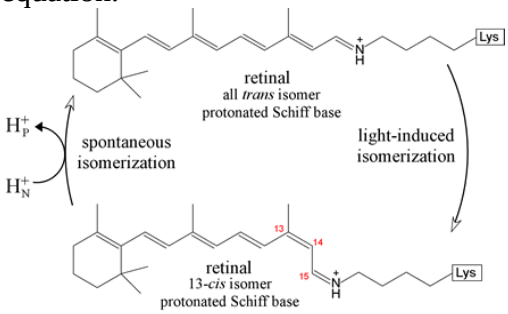
B. What fraction of the incident light makes it through the cuvette at this concentration?

Fraction of light transmitted = _____.

C. What flux ($F = W/cm^2$) is required for a 10 picosecond pulse at 400 nm to excite 10% of the sample? Hint: you may assume that each photon that strikes the cross section is absorbed.

Flux = _____.

3. The structure of retinal is shown in the figure below. To understand the absorption spectra, of all-trans and 13-cis retinal, one can use a free electron model. In this model one assumes that the retinal can be treated as a particle in a box. In the free electron model you may assume that the electrons from the p-orbitals of the carbon atoms populate energy levels derived from the particle-in-a-box solution to the Schrödinger equation.



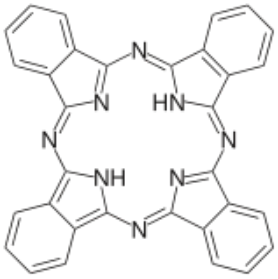
A. Assuming that the box length 13 Å with 10 electrons for all-trans retinal and 10.5 Å with 8-electrons for 13-cis retinal, please calculate the wavelength maximum of the absorption spectrum of each (in nm).

Wavelength maximum of all-trans retinal = _____.

Wavelength maximum energy of 13-cis retinal = _____.

4. The structure of phthalocyanine (Pc) is shown in the figure. To understand the absorption spectra of Pc, one can use a free electron model for a particle on a circle assuming that there are 18 p-electrons contributing. In the free electron model you may assume that the electrons from the p-orbitals of the carbon atoms populate energy levels derived from the particle-on-a-circle solution to the Schrödinger equation. The major difference of Pc relative to the more common porphyrins is that the effective radius of the circle is larger.

A. Assuming that the radius of the circle is 4.3 Å and that the Pc has 18 electrons, please draw an energy level diagram for this system.



B. Calculate the maximum of the absorption spectrum (in nm).

λ_{max} = _____nm.

C. Pc was accidentally discovered in 1907. It was observed as a compound with a deep blue color. The absorbance of Pc was determined to be 0.7 in a 0.4 cm path length cell at its λ_{max} when 8.1 mg of the compound was isolated from a volume of 1 liter. The molar mass of Pc is 514.5 grams/mol. Determine the molar extinction coefficient at the λ_{max} of Pc.

Extinction coefficient (units!) = _____.