Chemistry 2720 Fall 2001 Assignment 8

Due: Tuesday, Nov. 13, 9:25 a.m.

Important note: There will be a test on Thursday, Nov. 15. Since I won't be able to get this assignment marked before the test, this assignment is **optional**. If you decide not to hand in this assignment, its weight (2%) will be transferred to the final exam. You are still highly encouraged to complete the assignment, but I realize that you may want to focus your study time elsewhere. Note that the solutions will be discussed in class on Nov. 13 in preparation for the test so that you should at least have looked at these problems, even if you don't hand in your solutions.

1. Low-pressure sodium (LPS) lights are now used extensively to light our streets. They have several advantages. First, they use far less energy than other commonly used street lighting fixtures. A 55 W LPS fixture produces as much light as a 400 W incandescent lamp. The yellow light (wavelength = 550 nm) produced by LPS lamps also interferes far less with optical telescopes than does light from other sources because it can easily be filtered out. Supposing that all of the energy goes into the generation of photons, how many photons does a 55 W LPS lamp emit per second? [4 marks]

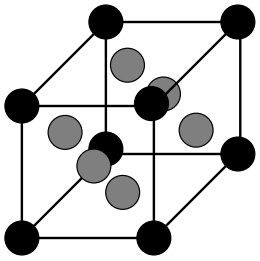
2. In photochemistry, we use photons to initiate reactions, usually by breaking bonds. Suppose that we wanted to add chlorine to a molecule and that we thought we could initiate the reaction by breaking the Cl_2 bond. The bond enthalpy (the enthalpy change for the reaction $Cl_{2(g)} \rightarrow 2Cl_{(g)}$) is 242 kJ/mol at 298.15 K.

   (a) Enthalpy is heat at constant pressure, but photons aren't "heat" in any reasonable sense of the word. It is better to think of them as bundles of energy. Calculate the bond energy for chlorine. [3 marks]

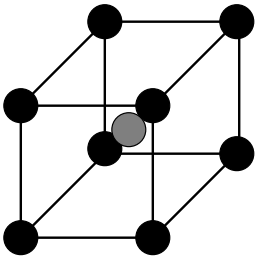
   (b) Calculate the frequency of a photon which can break the Cl_2 bond. To which spectral region does this frequency correspond? [4 marks]

   (c) The absorption of a photon must change the momentum of the centre of mass of the two chlorine atoms. What is the change in the speed of the centre of mass? Assume that both chlorine atoms are the mass-35 isotope whose mass is 34.9688 amu. [6 marks]

3. It is possible to determine the type of crystal from the pattern of reflections in an X-ray diffraction experiment. For instance, there are three variations on the cubic symmetry called simple, face-centered and body-centered. The simple cubic structure is the simplest case in which all the atoms are at the corners of a cube. In the face-centered arrangement, there are also atoms in the centres of the faces:



In the body-centered arrangement, there is an atom in the center of the cube:



Note that in both cases, the shading is only intended to distinguish corner atoms from the others and is not intended to indicate different types of atoms.

Each of these lattice types has different ratios of interplanar distances:

Simple cubic	$d_{100} : d_{110} : d_{111} = 1 : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$
Face-centered cubic	$d_{100} : d_{110} : d_{111} = 1 : \frac{1}{\sqrt{2}} : \frac{2}{\sqrt{3}}$
Body-centered cubic	$d_{100} : d_{110} : d_{111} = 1 : \frac{2}{\sqrt{2}} : \frac{1}{\sqrt{3}}$

Ammonium chloride produces a diffraction pattern with the following first-order reflections when the X-ray wavelength is 1.537 Å:

Reflection	θ (degrees)
100	11.45
110	16.30
111	20.12

What is the crystal structure of ammonium chloride? [10 marks]