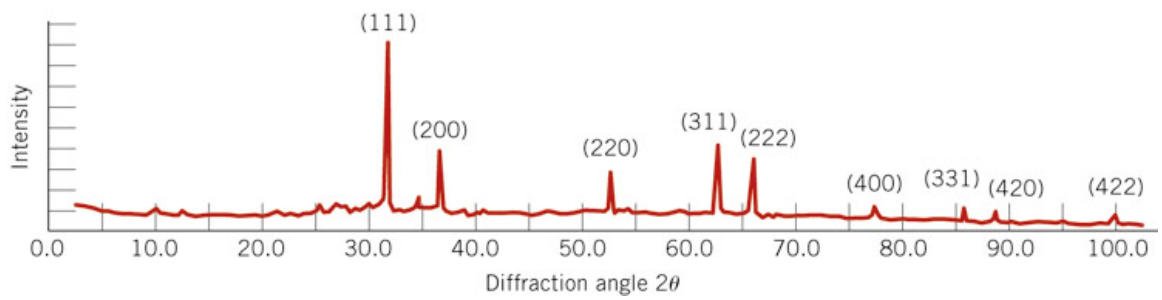
PHYS 225: Applications of Modern Physics **Marie Lopez del Puerto**

HW #11

1. The figure below shows an x-ray diffraction pattern for lead taken using a diffractometer and monochromatic x-ray radiation having a wavelength of 0.1542 nm; each diffraction peak on the pattern has been indexed. The peaks are at: 31.3°, 36.6°, 52.6°, 62.5° and 65.5°.
   a. Determine the structure of lead (simple cubic, BCC, FCC)
   b. Compute the interplanar spacing d for the first five sets of planes indexed.
   c. Determine the lattice parameter and atomic radius of lead for each of the first five peaks, and compare to the accepted atomic radius of 0.175 nm.



Note: for simple cubic $a = 2R$, for BCC: $a = 4R/\sqrt{3}$, and for FCC: $a = 2\sqrt{2}R$

2. **(Kasap 3.1) Photons and photon flux**
a. Consider a 1 kW AM radio transmitter at 700 kHz. Calculate the number of photons emitted from the antenna per second.
b. The average intensity of sunlight on Earth's surface is about 1 kW/m^2. The maximum intensity at a wavelength around 800nm. Assuming that all photons have an 800 nm wavelength, calculate the number of photons arriving on Earth's surface per unit time per unit area. What is the magnitude of the electric field in the sunlight?
c. Suppose that a solar cell device can convert each sunlight photon into an electron, which can then give rise to an external current. What is the maximum current that can be supplied per unit area (m^2) of this solar cell device?

3. **(Kasap 3.2) Yellow, cyan, magenta and white** *Three primary colors*, red, green, and blue (RGB), can be added together in various proportions to generate any color on various displays and light emitting devices in what is known as the *additive theory of color*. For example, yellow can be generated from adding red and green, cyan from blue and green, and magenta from red and blue.
a. A device engineer wants to use three light emitting diodes (LEDs) to generate various colors in an LED-based color display that is still in the research stage. His three LEDs have wavelengths of 660 nm for red, 563 nm for green, and 450 nm for blue. He simply wishes to generate the yellow and cyan by mixing equal optical powers from these LEDs; *optical power* or *radiant power* is defined as the radiation energy emitted per unit time. What are

the numbers of red and blue photons needed (to the nearest integer) to generate yellow and cyan, respectively, for every 100 green photons?

b. An equi-energy white light is generated by mixing red, green, and blue light in equal optical powers. Suppose that the wavelengths are 700 nm for red, 546 nm for green, and 436 nm for blue. Suppose that the optical power in each primary color is 0.1 W. Calculate the *total photon flux* (photons per second) needed from each primary color.

c. There are bright white LEDs on the market that generate the white light by mixing yellow (a combination of red and green) with blue emissions. The inexpensive types use a single bue LED to generate a strong blue radiation, some of which is absorbed by a phosphor in front of the LED which then emits yellow light. The yellow and the blue passing through the phosphor mix make up the white light. In one type of white LED, the blue and yellow wavelengths are 450 nm and 564 nm, respectively. White light can be generated by setting the optical (radiative) power ratio of yellow to blue light emerging from the LED to be about 1.74. What is the ratio of the number of blue to yellow photons needed? (Sometimes the mix is not perfect and the white LED light tends to have a noticeable slight blue tint.) If the total optical power output from the white LED is 100 mW, calculate the blue and yellow total photon fluxes (photons per second).