Physics 214 PreLab 2

Photons

Name _____

Section _____ **Date** _____

Your TA will collect this paper at the beginning of your lab section

Readings: **Physics 214 Lectures 4-5**

Young and Freedman 36.5, 38.2

1. The filament of a standard 100-W light bulb has a resistance of about 100 ohms. For this laboratory the glass of the light bulb is unfrosted, so that the filament can be viewed directly. The light bulb is connected to a variable AC voltage source (a Variac), which can deliver up to 140 volts AC. When the voltage is low, about 20 volts, the filament is a dull, red color. When the voltage is high, 100 V, how does the filament appear? Explain why. Hint: At a higher filament temperature, photons with higher energies can be emitted in addition to low energy photons.

2. When an electron in an atom makes a transition between two energy levels, E_{high} and E_{low}, a photon is emitted. If the photon is in the red portion of the visible light spectrum, what is its wavelength* and what is the energy difference between E_{high} and E_{low}? A figure in almost any physics text showing the spectrum of colors might be helpful. A useful web site is: https://en.wikipedia.org/wiki/Spectral_color

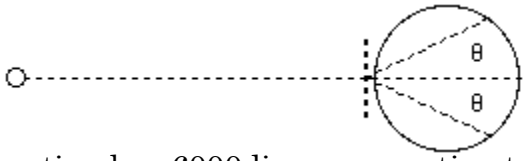
$\lambda =$ nm	$E_{high} - E_{low} =$ eV

What are the wavelength and the energy difference for a blue photon?

$\lambda =$ nm	$E_{high} - E_{low} =$ eV

* Obviously what we mean by "red" is a range of colors. Here you are to estimate the *average* wavelength.

3. A student holds a diffraction grating close to her eye and looks straight ahead at a source of blue light. With the light source straight ahead the light enters her eye at normal incidence. The undiffracted light from the grating falls on the back of her retina. The diffracted light from the grating falls to either side of her retina.

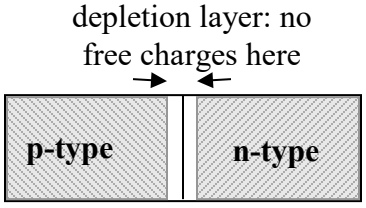


If the diffraction grating has 6000 lines per centimeter, what is the angle between the two diffracted beams? If the source is changed to red light, is the angle larger or smaller?

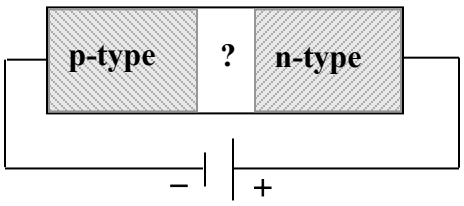
For blue light, the angle 2θ = _____deg	For red light, the angle 2θ =_____deg

4. In this lab you will be using Light-Emitting Diodes (LEDs) as a source of photons. A diode is a semi-conductor device that usually only passes current in one direction, a very useful property in circuits. Semiconductors come in several varieties. In a diode there are two adjacent materials, one that has a slight excess of free electrons (known as "n-type", because it has more negative carriers), and one that has extra "holes" for electrons to go (known as "p-type", because it has a deficit of free electrons, and therefore has net positive carriers). [You can think of a "hole" like an empty spot on a crowded freeway – one car can move into it, but that leaves the gap somewhere else. A "hole" has a positive charge of 1.6 x 10^{-19} Coulombs, just the opposite of an electron. Both electrons and holes can carry current.]

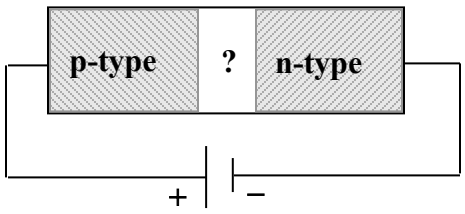
In a diode with no voltage across it (as shown at right), there is a small region, known as the depletion layer, where the extra electrons of the n-type material leak over to "fill in" the holes of the p-type material. In this region there are essentially no free charge carriers, and therefore, no possibility to conduct a current through the diode.



What happens when we put a voltage across the diode? Considering the diagrams below, circle your answer to what will happen to the thickness of the depletion layer for each orientation of the battery. Hint: Think about whether the electrons/holes will be attracted or repelled from the nearby terminal of the battery.



Depletion layer thickness will: increase/decrease



Depletion layer thickness will: increase/decrease

When the voltage across the diode is high enough (and in the correct orientation), the electrons in the depletion zone are boosted out of their holes and begin moving freely – the depletion zone disappears, and the diode conducts! A free electron moving across the diode can fall into an empty hole from the p-type material. This involves falling to a lower energy state (from the conduction to the valence band, as we will study at the end of Physics 214), and releases energy in the form of a photon.