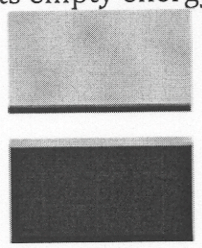
PHYS 225 – Spring 2010

HW #27

Due on Wednesday May 12

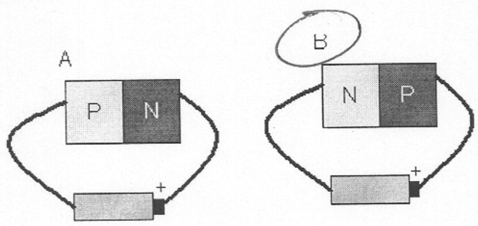
1. An electron energy diagram is drawn below. Black represents levels filled with electrons and grey represents empty energy levels.



This material is a ____________.
When hooked to a battery, some electrons in the lower band will ____________.
When hooked to a battery, some electrons in the upper band will ____________.

a) conductor, move, move
b) semi-conductor in the dark, not move, move.
c) semi-conductor in the light, move, move.
d) semi-conductor in the light, not move, move.
e) insulator, not move, not move.

2. a) A diode (where current is only allowed to flow one way through) is made by joining a P and an N-type semiconductor. Which of the following configurations allows electrons to flow?



b) In each of the drawings above, electrons in the right-hand piece of the junction feel a force:

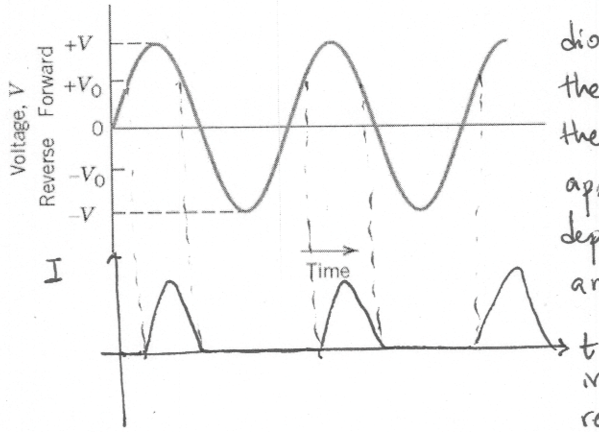
✓Towards the positive end of the battery
Away from the positive end of the battery

c) Explain why electrons flow in one case and not the other case? Be sure to connect your reasoning up to the main reason why electrons are generally allowed to flow in conductors, but not insulators.

in case A, electrons + holes are pulled away from the junction, so that no charge is moving through the junction (the depletion layer grows) and thus there is no current.

in case B, electrons + holes are pulled toward the junction, making the depletion layer smaller and allowing a current to flow.

3. A diode can be used to transform an alternating current into a direct current. The curve below represents input voltage vs. time for a PN junction. Make a plot of current vs. time for this junction, and explain the important characteristics of your plot.

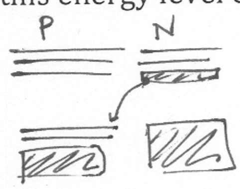


There is no current when the diode is reverse biased or when the forward bias is smaller than the built-in potential, V_0. As the applied voltage gets larger, the depletion layer becomes smaller and the current increases.

Note: this is an "ideal" PN junction, in reality there is a small current for reverse biase + voltages smaller than V_0.

4. Modern rear bike lights use red light emitting diodes or LEDs. Like any other diode, an LED allows current to flow through it in only one direction. But unlike a normal diode, an LED emits light.

a) In an LED, electrons conducted across the PN junction of a diode, emit a photon of light. Light is a form of energy. Where does this energy come from as the electrons move across the junction of the n-type and p-type semiconductors? Consider the energy level of the moving electron. How does this energy level change between the n-type and p-type part of the diode?



The energy comes from the battery, which gives potential energy to the electrons, putting them into the conduction band on the N side. As the electrons move to the P side, they lose this potential energy and emit a photon.

b) True / False:

True 1. The greater the current, the brighter the LED.

False 2. The greater the difference between the lowest energy level in the upper band of the n-type and the highest energy level in the lower band of the p-type, the longer the wavelength of light produced. (more energy → shorter wavelength)

False 3. If you put the batteries in backwards in you LED bike light, it will work the same. No current will flow, so no light!

c) If the LED emits red light (620nm), what will be the approximate measured voltage drop across the diode (in volts)?

$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV nm}}{620 \text{ nm}} = 2\text{ eV}, \quad V = \frac{E}{e} = \frac{2\text{ eV}}{1.6\times10^{-19}\text{ C}} \times \frac{1.6\times10^{-19}\text{ J}}{1\text{ eV}} = 2\text{ V}$$