Conceptual Physics Problems 08s: **LEDs & Electromagnetic Waves**

**Directions:** Work with a partner to solve the following problems. Show all work and label answers with the appropriate unit.

1. The Wikipedia entry on [Photovoltaic Cells](http://en.wikipedia.org/wiki/Solar_cell) gives the following simple explanation for the overall function of a solar photovoltaic:

**Simple explanation**

1. [Photons](http://en.wikipedia.org/wiki/Photon) in [sunlight](http://en.wikipedia.org/wiki/Sunlight) hit the solar panel and are absorbed by semiconducting materials, such as silicon.
2. [Electrons](http://en.wikipedia.org/wiki/Electrons) (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction.
3. An array of solar cells converts solar energy into a usable amount of [direct current](http://en.wikipedia.org/wiki/Direct_current) (DC) electricity.

Write a more detailed explanation, incorporating your knowledge of semiconductors, energy and electrons.

Answer must include specific reference to role of energy of photon, bandgap of semiconducting material, the one-way nature of photovoltaic cell design, and movement of electrons from valence to conduction bands within the cell.

1. [**Critical Thinking**] Read the [linked](http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/) article, paying particular attention to the diagram which shows the makeup of a multijunction photovoltaic cell.
2. Determine the band gap energies of each semiconductor used within the multijunction device. [Reference: [List of Band Gaps](http://en.wikipedia.org/wiki/Band_gap#List_of_band_gaps)]
3. What is the benefit of using several semiconducting materials in one solar cell?

You are able to convert more of the visible light into energy.

1. Why are most solar cells constructed with semiconducting materials with band gaps in the range of 1.4 eV – 2.5 eV?

This corresponds to the energy range of visible light.

1. Why would it be a mistake to make a solar cell out of Aluminum Nitride (AlN)?

AlN has a bandgap of 6.5 eV, which is well into the UV region, making it impractical for use in visible light solar cells.

1. Light travels at 3.00 x108 m/s in a vacuum, and for most practical purposes, through air as well.
2. Find the wavelength of a photon of light of frequency 5.09 x 1014 Hz emitted by a sodium vapor lamp.

589 nm

1. Determine the color of light described in (i).

589 corresponds to yellow light

1. What type of electromagnetic radiation would carry four times the energy per photon as the photon described in (i)?

Radiation with a wavelength of approximately 187 nm, which is ultraviolet light.

1. Optical microscopes are, at current design, unable to resolve objects smaller than 200 nm in size. Using the information from the Limitations section on Optical Microscopes, determine the frequency of electromagnetic radiation needed to resolve atoms (use the Carbon atom for analysis). What type of electromagnetic radiation is this?

Atoms are approximately 1 angstrom in size, which means that we would need light of approximately 1.9 x 10-10 m in wavelength, which are x-rays.

1. Electromagnetic radiation is useful in optical microscopes for observing objects that are quite small. How can we also use emission spectra to determine qualities of Stars which are millions of miles (and in cases, light years) away? Explain. [HINT: Think back to the “Neon and Other Discharge Lamps” PhET model. How could you distinguish between the gases in the tube?]

Each element has a unique spectral fingerprint, which means that if we look at the spetra of light emitted from stars, we can determine the composition of those stars.

1. Refer back to the original “problem” stated in LED Lab – Part 1. Write a detailed answer to the problem. Include an appropriately labeled illustration.