Photoelectric Effect

Work Function
Review/Practice Problems

Reminders:

- The intensity of the incident light does not affect the energy of the emitted electrons
- The electron energy depends on the frequency of the incident light, and there is a certain minimum frequency below which no electrons are emitted
- Electrons are emitted with no time delay

Einstein's theory:

- Light consists of "quanta"—***bundles (packets) of energy and momentum***
- The energy of the quanta is given by:

$$E = hf$$

  - Where ***f*** is the frequency of the incident light
  - And ***h*** is Planck's constant = 6.63×10^{-34} J·s
- Another name for "quanta" of light = ***Photon***

What does this mean?

- Light sometimes acts a particle with mass would
- HOWEVER, the amount of energy that is transferred during the collision of light with metallic atoms is dependent on the light's **frequency**, not mass…

So how does light cause an electron to be emitted from a metal surface?

- Electrons require a certain amount of energy to break free from their orbital around the atom
- If the electron has at least that amount of energy transferred to it through a collision with light photons, it will break free and be emitted with a certain amount of kinetic energy
- The kinetic energy of the electron is equal to the difference between the minimum energy required to break free and the amount of energy transferred in the collision:

$$E_k = hf - \phi$$

Work Function

- The "work function" is the equation used to determine the kinetic energy of an emitted electron: $$E_k = hf - \phi$$
- At the critical frequency, the incident energy will be equal to the work required to remove the electron, so: $$hf_c = \phi$$
- And $$E_K = 0$$

In addition…

- Since we know that the work done to remove the electron (and, therefore, its change in kinetic energy) is given by:

$$eV_s = E_K$$

- Then we also know:

$$eV_s = hf - \phi$$

- A photosurface has a work function of 1.50 eV. Find the critical frequency.

- If light of frequency 6.1 x 10^{14} Hz falls on this surface, what are both the energy and the speed of the emitted electrons?

- Monochromatic light of intensity 4.0 W and wavelength 4.0 x 10^{-7} m falling on a photosurface with a critical frequency of 6.0 x 10^{14} Hz releases 10^{10} electrons per second. What is the current collected in the anode?

- If the intensity of the light is increased to 8.0 W, what will the current be?

- If light of the same intensity (8.0 W) and wavelength 6.0 x 10^{-7} falls on this photosurface, what will be the current now?

Photon energy

- In addition to the photon's energy (E = hf), photons of light also carry momentum, given by the following equation:

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

- How many photons of wavelength = 5.0×10^{-7} m are emitted per second by a 75 W lamp, assuming that 1.0% of the energy of the lamp goes into the photons at this wavelength?

- If all of these photons hit a mirror and are reflected by it, what pressure do these photons exert on the mirror? Take the area of the mirror to be 0.50 m^2.