# Photoelectric Effect

Topics 13.1.1-13.1.4

Reading assignment: Pages 910-918
WebAssign: due Thursday, 3/3 by 7:25 AM

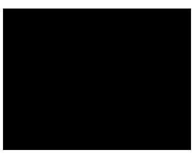


## Photoelectric Effect…What IS it?

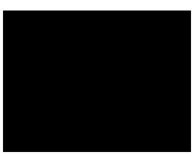
- A phenomenon in which electromagnetic radiation (light) falls on a metallic surface with enough energy to "knock" electrons off the metal, thereby potentially creating a current.
- Easily observed when a charged electroscope discharges because of its exposure to high energy light…
- Or a neutral electroscope becoming positively charged



## Photoelectric Effect Demos:



- Charging an electroscope through the photoelectric effect



- Discharging an electroscope with the photoelectric effect



## Photons…

- **Quantized** light
- The discrete "package", or Quantum, of light energy (discrete means there's a specific quantifiable value for this property)
- **<u>Einstein's Logic</u>:**
  - **<u>IF</u>** thermal energy (oscillations of atoms), for example, is quantized, then it stands to reason that the electromagnetic radiation <u>emitted</u> by that hot object ***should also be quantized***
  - If it's not, then energy isn't being conserved as thermal energy is transferred from a hot region to a cooler region



## Quantization: Planck's constant

- Remember black body radiation?
- Remember Wien's displacement law?
- Stefan-Boltzmann Law?
- But…these don't always work well for predicting intensities…
- Classical theory suggests: $I \propto \frac{1}{\lambda^4}$
- What happens at smaller wavelengths?
- ***Ultraviolet Catastrophe!!***



## Max Planck—German Physicist, 1900

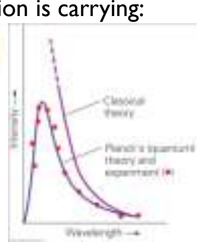
- Developed a theory to fix the "Catastrophe"…but needed to make several assumptions:
  - The atoms emitting the radiation (aka "Thermal Oscillators") have *discrete* (very specific) amounts of energy
  - The energy distribution was not just a general continuous distribution→

## Planck's Hypothesis:

- Frequency of emitted electromagnetic radiation is directly proportional to the energy that the radiation is carrying:

$E_n = n(hf) \quad \text{for } n = 1, 2, 3, \ldots$

- $h$ = Planck's Constant
  $= 6.63 \times 10^{-34}$ J·s






$E_n = n(hf) \quad \text{for } n = 1, 2, 3, \ldots$ *(Planck's quantization hypothesis)*

- Energy is only emitted in integral multiples of the quantity *hf*
- *Planck's constant is an <u>experimental value</u>*
- ***hf*** is known as the **quantum** of energy
- ***This hypothesis is used to explain quite a few phenomena that do not follow classical explanations***



## Back to light!

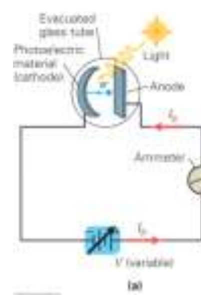
- Light has a frequency…therefore carries a discrete amount of energy according to Planck's hypothesis
- Remember:

$$E = hf$$

- Connects "wave nature" of light with "particle nature" of photons
- Used to help explain the nature of the Photoelectric Effect (since it can't be explained classically)



## Photoelectric Effect-review



(a)

- Cathode is a metal plate made of a photosensitive material
- Variable voltage maintained in order to provide a potential difference between cathode and anode
- Electrons are emitted (***photoelectrons***) from cathode and hit anode, creating a current (***photocurrent***)



## Computer Simulation:

- Using the Phet simulation, found here: http://phet.colorado.edu/en/simulation/photoelectric
- Collect data and create a graph for each of the following:
  - 1. Photocurrent as a function of Light Intensity (use your assigned wavelength)
  - 2. Photocurrent as a function of Light Frequency
  - (calculate the frequency using the relationship $c = f \cdot \lambda$)
  - 3. *For your assigned wavelength*—determine the ***minimum added voltage required*** in order to <u>prevent the electrons from ever reaching the anode</u>