

Name: _____

The Photoelectric Effect PhET Lab, Physics AP rvsd 2009

Introduction:

That light can diffract and refract tells us light behaves like a wave. We also learn that light sometimes behaves like a particle. How do we know that light behaves like a particle? The photoelectric effect leads us to this. How does your solar-powered calculator work? Solar PV cells (*photovoltaic*) convert the energy in light to electric energy (DC current). The same principles that allow a solar-powered calculator to work also act in your cell phone's digital camera. For those materials that we classify as *photosensitive* (most metals, metalloids), light comes in, electrons come out. *If we reverse the process...lasers...*



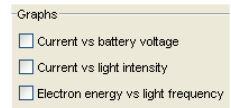
Photoelectric Effect

Important Formulas: $E = hf$ $E = pc$ $c = f\lambda$ $KE_{\max} = hf - \phi$ $\phi = hf_t$

$1.00eV = 1.60 \times 10^{-19} CV = 1.60 \times 10^{-19} J$ $h = 6.63 \times 10^{-34} Js$ $IV = 1J/1C$

Procedure, Part I: *PhET Simulations* → *Play With Sims* → *Quantum Phenomena* → *Photoelectric Effect* Run Now!

- Take some time and familiarize yourself with the excellent simulation. You can change the photosensitive metal observed, the light intensity (brightness), voltage added, and the very important EM wavelength.
- Remember...wavelength is used in the simulation, and frequency is used in the formulas. The product of the two is the speed of light, 3.00×10^8 m/s.
- Click on the boxes to show the graphs of I v V , I v A , and E v A
- Using sodium as our metal, change the wavelength to a value that just begins to cause current to flow.



Draw a sample graph of current vs intensity here

Threshold Wavelength required eject electrons from sodium: _____ nm

Threshold Frequency of this wavelength: _____ Hz

Maximum Energy of each photon used here: _____ J and _____ eV

- Next, set the wavelength to 400 nm and intensity to 50% record the current flow here: _____ A
- What effect does increasing the intensity (at this wavelength) have on the current flow? _____
- Set the wavelength to 700nm. What effect does increasing the intensity (at this wavelength) have on the current flow? _____ Why is this?

- Find the threshold wavelengths and frequencies for each of the photosensitive metals in the simulation. Then calculate the energy of the incident radiation for each photon incident upon the metals at that frequency.

Draw a sample graph of energy vs frequency here

Metal	λ (threshold) nm	f (threshold) Hz	E (J)	E (eV)
Na				
Zn				
Cu				
Pt				
Ca				
??				

Metal	λ (threshold) nm	f (threshold) Hz	E (J)	E (eV)
Na				
Zn				
Cu				
Pt				
Ca				
??				

The Work Function, ϕ (pronounced “fee”)

In actuality, the energy of a photon is never directly proportional to the energy of an ejected electron because the electron must overcome a potential energy barrier (due to a number of quantum and molecular factors). We call this barrier the *work function*, ϕ . The kinetic energy of an ejected photon is the difference between the energy of the incident radiation and the work function, usually given in eV. The “eV” or electron-volt is an energy unit that results when one electron passes through a potential of one volt ($U_e = qv$). This is useful because (as you will do in the next step) if you know the energy (in eV) of an incident photon, and the voltage required to keep the ejected electron from moving (the *stopping potential*) you can calculate the work function of the metal you’re investigating.

Procedure, Part II:

- Using each of the metals in the simulation, select two wavelengths far below that metal’s threshold and then adjust potential until the electrons are stopped. Fine adjustment of the potential (voltage) will **require you to input values using the keyboard**. Complete the data table below. Remember, for each electron $\rightarrow V \sim eV$

Metal	λ , nm \leftarrow you choose \rightarrow	f, Hz	E (J)	E (eV)	V(stopping, eV)	ϕ (eV)
Na						2.28 eV
Na						2.28 eV
Zn						
Zn						
Cu						
Cu						
Pt						
Pt						
Ca						
Ca						
??						
??						

Calculations Questions:

- The line on the graph of current to intensity can be described as _____
- The line on the graph of energy to frequency can be described as _____
- At a frequency below the frequency required to overcome the work function, increasing the light intensity causes the current to *increase / decrease / remain the same*.
- At a frequency above the frequency required to overcome the work function, increasing the light intensity causes the current to *increase / decrease / remain the same*.
- Old darkrooms (for developing film) were once illuminated with a faint red light (765nm). If this was the limit of the silver compound used in the film, solve for the work function of the silver compound. _____
- Consider the following scenario: On a partly cloudy day you find that a household PV array outputs 2.4 amps of current. If the clouds part and the sun comes out, exactly doubling the amount of light incident on the PV array, we should expect the array to output *2.4 A / 4.8 A / more than 4.8 A / less than 2.4 A / between 2.4 and 4.8 A*. (careful)
- Why? _____