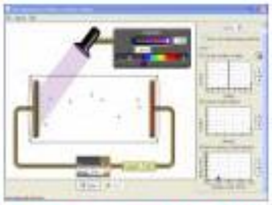
Name:____________________

The Photoelectric Effect PhET

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

$\boxed{1.00eV = 1.60x10^{-19}CV = 1.60x10^{-19}J}$ $\boxed{h = 6.63x10^{-34}Js}$ $\boxed{1V = 1J/1C}$

Part One:

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, $3.00x10^8$ m/s.
- Set the Intensity to 50%.
- Using sodium as our metal, change the wavelength to a value that just begins to cause current to flow. The electrons will be visible leaving the metal.

What is the longest wavelength required to eject electrons from sodium? ______________ nm

What is the frequency of this wavelength: ______________ Hz

What is the energy of the photons of this wavelength? ______________ 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? _________________________ Explain:

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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.

Fill out data table one. Keep the intensity at 50%.

Data Table One:

Metal	λ (threshold) nm	f (threshold) Hz	E (J)	φ, 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.

Part Two:

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**. Keep the intensity at 50%.

Complete the data table two. For a single electron V in the simulated voltmeter becomes eV

Data Table Two

Metal	λ, nm	f, Hz	E (J)	E (eV)	V(stopping, eV)	φ (eV) calculated **E(eV)-|V(stopping)|**	φ (eV) **measured (Table 1)**
Na							
Na							
Zn							
Zn							
Cu							
Cu							
Pt							
Pt							
Ca							
Ca							
??							
??							

Answer Questions

1. The line on the graph of current to intensity can be described as _____________

2. The line on the graph of energy to frequency can be described as _____________

3. 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.*

4. 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.*

5. Choose one of the metals and compare the calculated values of the work function to the measured values (table two). Determine the percent difference. Percent difference = ABS[calculated-measured]/calculated expressed as a percentage.

6. Choose one of the metals and compare your work function (calculate percent error) value from Table One to the Table of Values at this link:
   https://justonly.com/chemistry/chem201/students/labs/workfunctionvalues.pdf

   Percent error = ABS[measured-literature]/literature expressed as a percentage.

7. Evaluate this simulation. In what ways was it useful? In what ways was it confusing?