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| **Pre-AP** | PE02481_ | **ModernPhotoelectric Effect Lab** | Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Teacher \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Period \_\_\_\_\_ |

**Background**

Physics was at its pinnacle of understanding the natural world as of 1900. Only three things had yet to be explained. Physics assumed once blackbody radiation, photoelectric effect and atomic spectra were explained that the study of physics would be complete. The assumption was wrong and led to a new branch of physics known today as quantum mechanics.

This lab will investigate the photoelectric effect. The photoelectric effect is the emission of electrons from a surface when illuminated with light of a certain frequency. The first insight to understanding this phenomenon was presented in 1900 by Max Planck. His formula, E = hf, related the energy of a photon to its frequency. Albert Einstein extended this idea of quantized photonic energy to a stream of photons (electromagnetic radiation) and explained the photoelectric effect.



**Part 1**

Objective - What is the relationship between the energy of a photon and its frequency?

Qualitatively graph photonic energy versus frequency on the axes to the right.

**Part 2**

Objective - What determines if electrons are ejected from the surface?

1. Go to <http://phet.colorado.edu/simulations/sims.php?sim=Photoelectric_Effect> and launch the simulation.
2. Make the following adjustments to the simulation once it has launched.
* Increase the intensity to 50%
* Check the box “electron energy vs light frequency”.

Once these adjustments have been made you should notice the ejection of elections from the surface.

1. Increase the wavelength of the light until electrons are no longer ejected. Record the wavelength in the table below and complete the calculations. 1 electron-volt (eV) = 1.6 X 10-19 J
2. Repeat the above step for each of the metals under the pull down menu.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Metal** | **Wavelength (nm)** | **Frequency****(Hz)** | **Energy** **(J)** | **Energy** **(eV)** |
| Sodium |  |  |  |  |
| Zinc |  |  |  |  |
| Copper |  |  |  |  |
| Platinum |  |  |  |  |
| Calcium |  |  |  |  |

|  |  |
| --- | --- |
| **Metal** | **Threshold Frequency (Hz)** |
| Sodium |  |
| Zinc |  |
| Copper |  |
| Platinum |  |
| Calcium |  |

1. The minimum frequency of a photon that can eject an electron from a surface is called the threshold frequency, ft. What is the threshold frequency, ft, for each of the metals?

**Part 3**

Objective - What determines the energy of the ejected electrons?

|  |  |  |
| --- | --- | --- |
| **Metal** | **Work Function****(J)** | **Work Function (eV)** |
| Sodium |  |  |
| Zinc |  |  |
| Copper |  |  |
| Platinum |  |  |
| Calcium |  |  |

1. The minimum amount of energy required for an electron to escape from a metal is called the work function, W, and is given by the equation W = hft. Calculate the work function for each of the metals in joules and electron-volts using the threshold frequencies for each metal.
* h = 6.63 X 10-34 Js or h = 4.14 X 10-15 eVs
1. When an electron is ejected from the surface, what type of energy does the electron possess?
2. Below is a graph of electron energy vs light frequency for platinum. Record and identify the following on the graph.



* The threshold frequency.
* The range of frequencies that give an electron a kinetic energy greater than zero.
* The range of frequencies that do not eject an electron.

**Part 4**

Objective - What affects the number of ejected electrons?

1. Make the following additional adjustments to the simulation.
* Check the box “current vs light intensity”.
* Select the metal platinum.
1. Adjust the frequency of the incident light slightly above the threshold frequency.
2. Vary the intensity of the light and observe any changes in the number of ejected electrons.
3. Increase the frequency of the incident light until it is well above the threshold frequency.
4. Vary the intensity of the light and observe any changes in the number of ejected electrons.

**Part 5**

Objective - What determines if the photoelectric effect occurs?

1. What’s the relationship between the frequency of the incident photon, threshold frequency and the ejection of electrons?
2. What’s the relationship between the energy of the incident photon, the work function and the ejection of electrons?
3. What’s the relationship between the kinetic energy of the ejected electrons, the energy of the incident photon and the work function?
4. What’s the relationship between the intensity of the incident light and the average kinetic energy of the ejected electrons?
5. What’s the relationship between the intensity of the incident light and the number of the ejected electrons?

**Related Problem Bank Problems #1, 2, 3, 4, 5**