The Photoelectric Effect

**Object:** To verify the predicted relationship between maximum electron energy and light frequency in the photoelectric effect and to determine the value of Plank's constant.

**Theory:** When a metal is illuminated by electromagnetic radiation of sufficiently high frequency, it emits electrons. How many electrons it emits is dependent on the intensity of the light, and the average energy of the electrons is dependent on the frequency of the light. Electrons are emitted because when a photon collides with an electron, the electron absorbs it as well as its energy. Some of the energy of the photon is used to overcome the binding energy of the metal, and the rest is manifested as kinetic energy. The bonds between the electron and the metal are not all equally strong, thus the electrons that are bound weakest will have the most kinetic energy, and all other electrons will have less. The maximum kinetic energy of the electrons varies linearly with light frequency, but if the light is not of high enough frequency, no electrons will be emitted because the photons do not have sufficient energy to overcome the work function of the metal (which is a measure of how much energy is required to remove and electron from the metal). This phenomenon is called the photoelectric effect, and it can only be explained with the particle theory of light.

*List of equations:*

KEmax = *e*Vo

KEmax= *hf* - w

*List of variables*

KEmax = Maximum kinetic energy of electron

*e=* elementary charge

*h* = Plank`s constant

*f* = frequency of light

w = work function of metal in phototube

**Experiment:**

The maximum kinetic energy of photoelectrons produced by different intensities and frequencies of light was determined in this experiment. This was done by measuring the stopping potential (the retarding voltage required to reduce the current emitted by a piece of metal in a phototube to zero) of various intensities and frequencies of light. A high intensity mercury vapour light was the light source, frequency filters were used to isolate discrete frequencies of light, and intensity filters were used to alter the intensity of the light. Retarding voltage was increased gradually until the current reached zero, so that even the most energetic electrons could not reach the anode. These highest energy electrons must have had energy equal to the product of the stopping potential and the charge of the electron. The value of the stopping potential was determined by analyzing a computer generated graph of the current output verses retarding voltage.

**Discussion:** Our data agreed with the relationship predicted by theory. We obtained a value of (3.93 +/- 0.20) x 10-15 eV·s for Plank`s constant and a value of 1.46 eV for the work function of the metal in the phototube. Maximum kinetic energy of electrons emitted depended linearly on the frequency of the light and did not depend on the intensity of the light. The main source of error in our measurement of the stopping potential was light from outside the room, which contradicts our assumption that the only photons incident on the metal were of a single discrete frequency.

**Conclusion:** Our results suggest that Einstein`s equation is correct. the quantization of light into photons does well to explain why the maximum energy of the electrons does not depend on intensity and also why there is a critical energy that must be overcome before the electron is emitted.

**Summary:** In this experiment we verified the relationship predicted by theory that in the photoelectric effect the energy of photoelectrons varies linearly with the frequency of incident light. We determined a value for Plank`s constant that agrees with the currently accepted value. We did this by relating the maximum kinetic energy of the electrons to the retarding voltage that just barely stopped all electrons from leaving the tube, and plotting this maximum energy against frequency of light to see if the relationship held.