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# Experiment 9

# Planck's Constant–Method 2

The Einstein photoelectric equation relates the kinetic energy $K$ of the emitted electron to the frequency of the radiation falling on the emitter and the energy required to extract the electron from the material

$$K = h\nu - eV_0,$$

where the extraction energy is written as the product of the magnitude of the electron charge and a potential $V_0$ known as the work function of the material. Unless

$$h\nu > eV_0$$

no electrons will be emitted. If the emitter is used as the cathode of a vacuum cell and connected to the other electrode, or anode, a current will exist in the circuit as long as light of sufficiently short wavelength falls on the cathode. If a retarding potential is applied between anode and cathode in the external circuit the current will be reduced. The current will be zero if the retarding potential is set at the value $K/e$. In the experiment you will measure the retarding potential required to stop the photoelectric current as a function of frequency, or reciprocal wavelength. A value of $h$ will be calculated from the graph of the "stopping" potential versus reciprocal wavelength.

The photocell has a potassium cathode and a ring anode set so that light can reach the cathode without striking the anode. The cell is connected to a low leakage small value capacitor so that the capacitor charges as the photo current is generated. The potential difference between the capacitor plates approaches the stopping potential, the photo current is reduced by the electric field between anode and cathode, and eventually the voltage across the capacitor reaches a steady value. This value is the stopping potential plus any contact EMFs arising from the connections between circuit elements. These unknown voltages only affect the intercept of the graph and can be ignored.

The incident light is provided by a microscope illuminating lamp and condensing lens. The frequency is selected with a narrow band pass Fabry-Perot filters. Care must be taken to ensure that the light does not strike the anode and cause the emission of electrons from its material or from small amounts of potassium acquired in the manufacturing of the cell. The cell must also be shielded from room light.

The steady potential reached by the capacitor is measured by an electrometer rather than a voltmeter. The input impedance of the electrometer is so high that it does not provide any significant drain for the charge on the capacitor. Such is not the case for everyday voltmeters. The potentials measured will lie in the range 0.3 to 1.2 volts (approximately). Use filters for wavelengths 650, 600, 550, 500, 450 nm with the microscope lamp. Then substitute a mercury lamp without filter to get the stopping potential for the 404.7 nm line. (The glass lenses prevent the ultraviolet lines of mercury from reaching the cell.) Plot a graph of stopping potential versus reciprocal wavelength and determine Planck's constant and the apparent work function of potassium. Record the stopping potential for the microscope lamp without any filters and use your other results to determine the short wavelength limit of the emission from the lamp.