Experiment E-10

Photoelectric Effect: h/e

Utilizing the 929 photocell in the arrangement supplied (S-4 photo surface), we are to check Einstein's photoelectric equation and determine h/e.

Obtain data for and plot an I vs. V curve between +22 1/2 and -22 l/2 volts for each of several different frequencies of radiation isolated from the Hg discharge lamp by filters on filter wheels. To minimize suspected charging effects on the glass envelope of the photocell, start with the longest wavelength first (yellow filter), proceed in sequence to successively shorter and shorter wavelengths. At each wavelength, experimentally normalize the maximum current (obtained at +22 1/2 volts) to the maximum obtained with the yellow filter (lamp fairly close in to the cell but not so close as to produce appreciable heating) by moving the Hg lamp suitably away from the phototube. In the region of stopping potentials, take fairly close data (More than at voltages well removed). Various trickery (fakery?) has to be employed to extrapolate the plot to zero forward current. Reverse current is minimized by pasting an opaque strip up the front of the photocell to shadow the central collecting wire from direct incident light. Reverse current should be as small as half or a third of a percent of the maximum forward current, minimized by lifting the source laterally. Understand your simple circuitry and the operation of the Model 410 Kiethley electrometer, which minimizes the effect of the input voltage drop. From the superposed plots, determine the constant potential and understand the method.

For each plot determine the stopping potential and thus h/e from a plot of these voltages vs. frequency. The experiment notes indicate various means to best determine these values.

Using the Keithley Model 210 electrometer at is highest input sensitivity , determine the stopping potentials directly. On the previous plots to what values do these correspond? Why? From these values determine an h/e value. --- For one wavelength, change the intensity of the light and compare the stopping potential with that obtained previously.

References

1. Richtmyer and Kennard, *Introduction to Modem Physics,* 4th Ed pp. 71-108. 2. Hughes and DuBridge, *Photoelectric Phenomenon,* pp. 71-108.

Notes on E-10

3-1-74

Several versions of this experiment have been tried over the years, ~ including the use of a photomultiplier connected simply as a diode. The old set up, Used n years ago, With a simple diode(now in s-4 photosurface-- the 929 phototube) and a fed back Kiethley micrometer (the feed back feature avoids the annoying and somewhat defeating necessities for correcting the applied voltage for the voltage drop through the electrometer resistor, in tJ fed back instrument the voltage drop is about 1 mv.) seems to work better than anything heretofore. One od two features should be noted. There is a strip of black masking tape up the front of the phototube to put the anode (collector) wire in shadow to make the reverse current low. It can be made well below 1/2 or 1/3 %of the forward saturation current. To the contact potential determination, one normalized them all to the same value in the experiment. The yellow filter and mercury lamp produces the smallest photo- current in saturation(+20 volts is fine) This can be made almost full scale on the 10x10-7 scale of the meter, by bringing the mercury arc up fairly near the filter wheel. The other filters then are used with the mercury arc pulled back until the same value of saturation current is attained.

Then the retarding potential data are taken. The curves intersect nicely. Th phototube should be reasonably well <u>covered and against against the filter wheel.</u> It will be observed that while the filter forward. Currents are normalized to the same value, the reverse currents are not for some odd reason.

The closer the ars is, the larger is the reverse current. Typically with The saturation forward current about 10*10^-7 amp, the reverse current will be saturated at 1 to 3x10-9 amps. One can lift the top of the photocell case to insure that the central wire is in shadow.

While one should make rough plots from -20 to +20 volts, the most closely spaced data should be taken in the region of the cut-off on up to a few tenth of a volt positive, beyond the intersection point, It is still a problem to determine the exact cut off point. There is always a tailing off into the reverse current characteristic. One would like to convert the curved characteristic into a straight line and extrapolate that into the voltage axis. He can plot the square root of the voltage and go that rout. Another rout is to regard the curved portion above reverse as an exponential and plot log of the current increments vs volts. Of- course that is ridiculous but if one plots things so near threshold, a fairly straight line results. And then if he fixes log of 1x10-9 as being un1ty, the plot extrapolates to log=O at pretty nice values for the voltage.

Clearly a fudge but probably as good as another trick. The student may come up with other ideas. (that log value for 1x10-9 assume that forward saturation is set to be close to 10x10-7 amps.)

Measured currents vary sharply in the vicinity of threshold and a good resolution voltage control would be useful. We will try to put an added heli-potentiometer in for this and use the simple one turn pot for the course adjustment in the higher voltage ranges, plus and minus.

To avoid possible effects from glass surfaces getting charged with photoelectrons, it is recommended that one start work with the yellow filter and proceed in tern with shorter and shorter wavelengths. It is not clear this is necessary but reason can be seen that it might effect things. Threshold voltages in principle can be read directly with the other Kiethly (non-fed back.) One simply turns the battery off and puts the meter on open circuit (or 1012 ohm input resistor) and reads the voltage on the two volt scale. It can be calibrated with the voltmeter. (Of course this voltage is not the cut-off voltage: what infact is it?)