Laboratory #8 : Photoelectric effect

Objectives : To study photoelectric effect by

Theory : Photoelectric experiment shows that the light is the particle. Einstein explained the photoelectric effect that the incident photon has energy $E = hf = h\frac{c}{\lambda}$, where h is Plank's constant, f is the frequency, c is velocity, and λ is the wavelength of light. Increasing the intensity of the light to increasing the number of incident photons per unit time while the energy of each photon remained the same; therefore, the number of ejected electron is greater. However, each electron carries the same average kinetic energy KE. In Einstein's model, in order to knock out the ejected electron, the incident energy of the photon has to have a sufficient energy, the work function $\emptyset$ of the target material. If the incoming photon hits the target material and give all of its energy to an electron, the chain reaction of energy is expressed as

$$KE = hf - \emptyset \qquad (1)$$

The incident light has a frequency less than a minimum frequency, threshold frequency. Then, no electrons are ejected regardless of light intensity. The relationship between photoelectron, kinetic energy and light frequency shows in Figure 8.1.

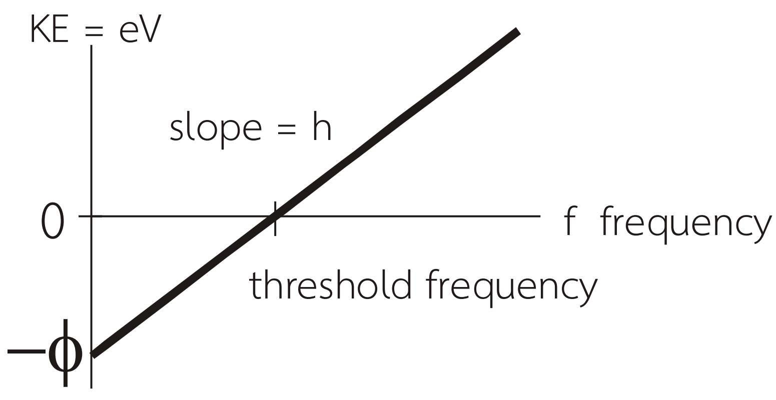

Figure 8.1 shows the relationship between the incoming photon frequency and the kinetic energy of photoelectrons.

The photoelectric effect experiment apparatus is shown in the Figure 8.2 a). There are two metal plates in vacuum, cathode and anode, adjustable forward voltage V between them. Cathode connects to the negative voltage having collective of negative charges. One the another hand, anode connects to the positive voltage having collective of positive charges. Incident photon having an energy greater than the work function $\emptyset$ hits the cathode metal, the electrons are ejected from the surface of cathode and running to the positive charge on the other side. The equation can be rewritten as

$$eV = hf - \emptyset \qquad (2)$$

The higher intensity brings higher number of ejected electrons; therefore, the higher photocurrent current shown in Figure 8.3. A reverse bias voltage applied to two metal plates shown in Figure 8.2 b). The gathering of negative charges prevents the reaching of photoelectron to the target plate. The photocurrent is decreasing.

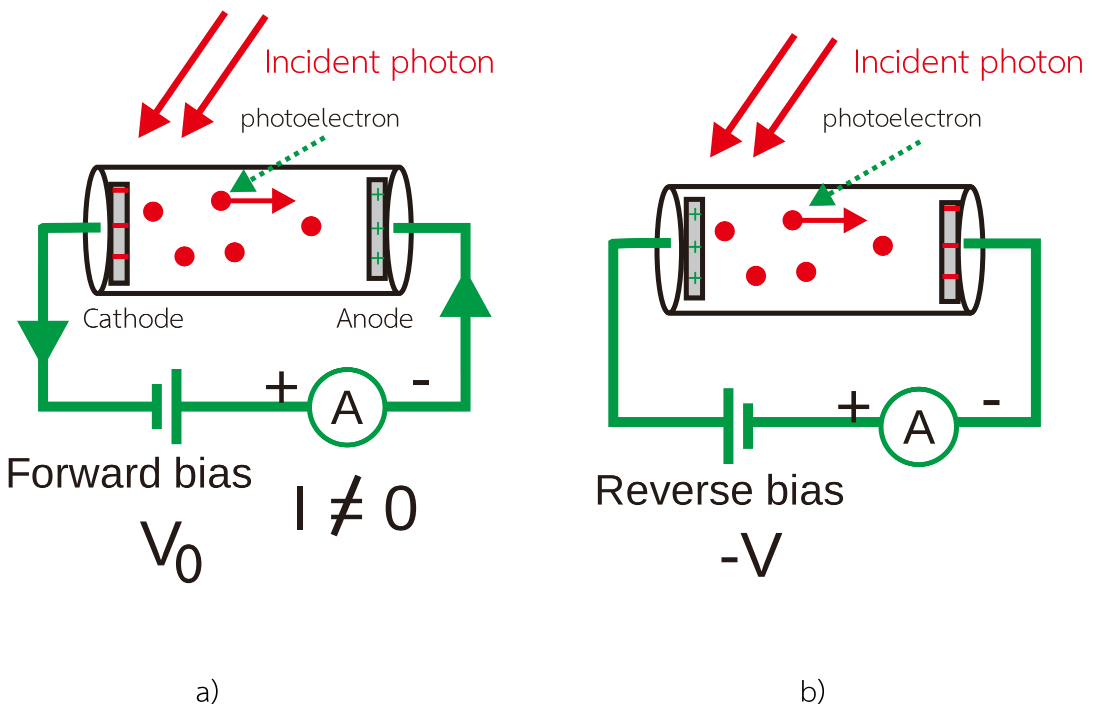

Figure 8.2 show a photoelectric experiment apparatus when the applied voltage is a) a forward bias and b) a reverse bias.

$1\ ev = qV = 1.602\ x\ 10^{-19}(c)*V\ (volts)$

$1\ ev = 1.602\ X\ 10^{-19}\ J \qquad h = 6.626\ X\ 10^{-34}\ J.s = 4.14\ X\ 10^{-15}\ eV.s$

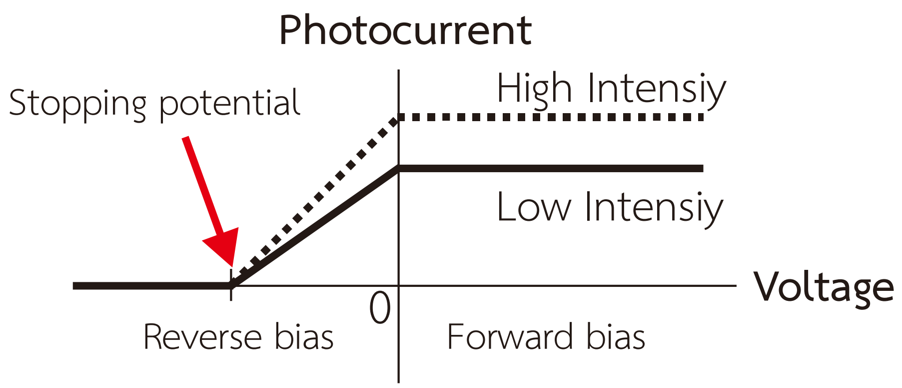

Figure 8.3 show the relationship between the photocurrent and the applied voltage both in the forward bias and reverse bias.

Experiment :

1. Set up an experiment as shown in Figure 8.4.

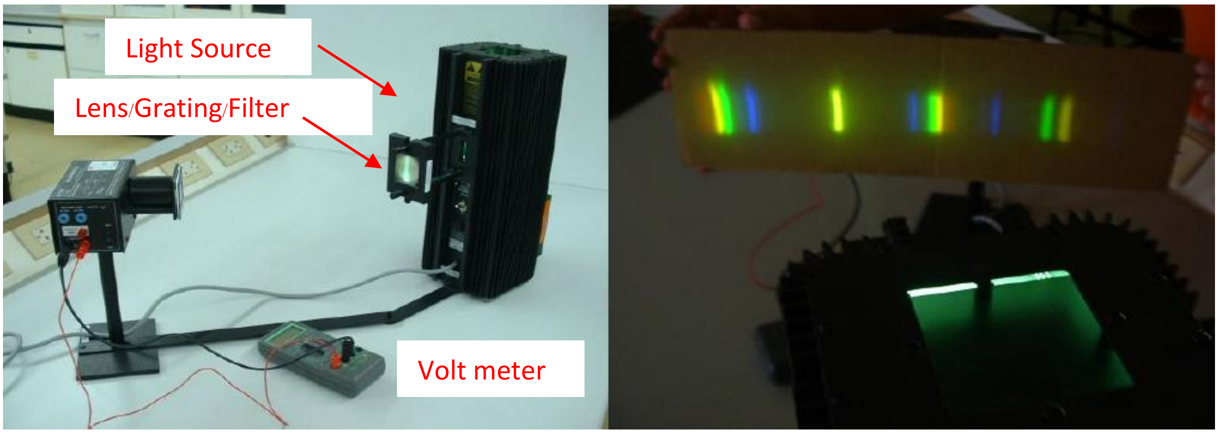

Figure 8.4 show a photoelectric experiment apparatus

2. Use a certain the wavelength.

3. Measure the stopping voltage of each wavelength at various intensity.

Color Filter ……..	Angle at the polarizer	% of Intensity	Stopping volatage **V**				
			# 1	# 2	# 3	$\bar{V}$	δV
Frequency (f) ……………………	0°	100					
	20°	88					
	30°	75					
	40°	59					
	60°	25					
Color Filter ……..	Angle at the polarizer	% of Intensity	Stopping voltage **V**				
			# 1	# 2	# 3	$\bar{V}$	δV
Frequency (f) ……………………	0°	100					
	20°	88					
	30°	75					
	40°	59					
	60°	25					

4. Plot a graph between the stopping voltage, y axis, and the percentage of light intensity, x axis.
5. Study the relationship between the stopping voltage and the frequency of light.

Wavelength (λ)	Frequency (f)	Stopping voltage			
		# 1	# 2	# 3	$\bar{V}$
508					
540					
552					
575					
602					
641					

6. Plot a graph between the stopping voltage, y axis, and the light frequency, x axis.
7. From the graph, determine the plank’s constant and the work function of the material.