5 EXPERIMENT Based on ELECTRONIC DEVICES

Experiment 5.1

To determine Plank's constant using Photocell.

Apparatus Required:

A photocell in a wooden box provided with wide slit, a galvanometer, rheostat, tapping key DC power supply, set of filters, one-way key, voltmeter, resistance box, connecting wires etc.

Theory:

When light of suitable frequency is allowed to fall on a metal surface, emission of electrons takes place. The emitted electrons are known as *photo electrons and phenomenon is called photo electric effect.*

The minimum energy required to just liberate an electron from metal surface is called *work function.*

According to Einstein's, when radiations of energy hν are allowed to fall on metal surface, the energy of incident radiations is partly used in liberating the electron from metal surface (work function) and rest of energy is given to emitted electron as its kinetic energy.

Therefore $\boxed{h\nu = W + \frac{1}{2}mv^2}$

where h = Planck's constant, ν = frequency of incident light, W = Work function, $\frac{1}{2}mv^2$ = K.E. of emitted photoelectron

The circuit used to find Planck's constant is as shown in Fig. 5.1. When circuit is closed there is current in the circuit even when no potential is applied. This is due to kinetic energy of emitted photoelectrons, thus, a negative potential has to be applied in order to make current zero. This negative potential is called *stopping potential.*

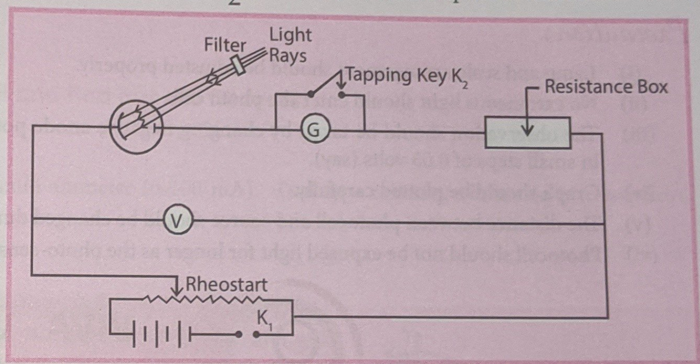

Fig. 5.1. Circuit used to find Planck's constant

If V be the stopping potential then, $\frac{1}{2}mv^2 = eV$ where V is stopping potential

So, $\boxed{h\nu = W + eV}$

Let, ν_1, ν_2 be the frequency of monochromatic light and V_1 and V_2 be the corresponding stopping potential, then

$$h\nu_1 = W + eV_1$$

$$h\nu_2 = W + eV_2$$

$$h(\nu_1 - \nu_2) = e(V_1 - V_2)$$

$$\boxed{h = \frac{e(V_1 - V_2)}{\nu_1 - \nu_2} = \frac{e\Delta V_0}{\Delta \nu}}$$

Procedure:

Step 1. Make electrical connections as shown in Fig. 5.1.

Step 2. Mount the wooden box containing photocell on an optical bench and fix source of light at a distance 60-70 cm in front of photocell at a same height.

Step 3. Switch on the light, place a suitable filter of known wave length (say blue, green or yellow) in its path and allow the light to fall on the photo-cathode of photocell, a deflection is observed in the galvanometer by tapping the key K_2. If deflection is out of scale then adjust the value of resistance from resistance box so that deflection is within scale.

Step 4. Go on increasing the negative potential applied to the anode of the photocell slowly so that the deflection on the galvanometer scale just reduces to zero. The voltmeter reading is recorded.

Step 5. Repeat the experiment by placing different filters *i.e.* of blue ; green; yellow and red colours and find the corresponding stopping potentials.

Observations:

Table 5.1.

Sr. No.	Filter Colour	Wavelength from standard	Frequency, $\nu = \frac{3 \times 10^{10}}{\lambda}$	Stopping Potential V_0 (volts)
1.	Violet	4050×10^{-8} cm		
2.	Blue	4360×10^{-8} cm		
3.	Green	5460×10^{-8} cm		
4.	Yellow	5780×10^{-8} cm		
5.	Red	6910×10^{-8} cm		

Calculations:

Plot a graph between stopping potential and frequency taking stopping potential along Y-axis and frequency along X-axis. Find the slope and the intercept of the graph as already explained.

$$h = e \tan \theta = 1.6 \times 10^{-19} \times \frac{\Delta V_0}{\Delta \nu} = \text{........ J sec.}$$

Photo electric work function

$$W_0 = e \times OC = 1.6 \times 10^{-19} \times OC \text{ Joule}$$
$$= OC \text{ electron-volt.}$$

$$\text{Percentage error} = \frac{\text{standard value} - \text{observed value}}{\text{standard value}} \times 100$$
$$= \text{..........\%}$$

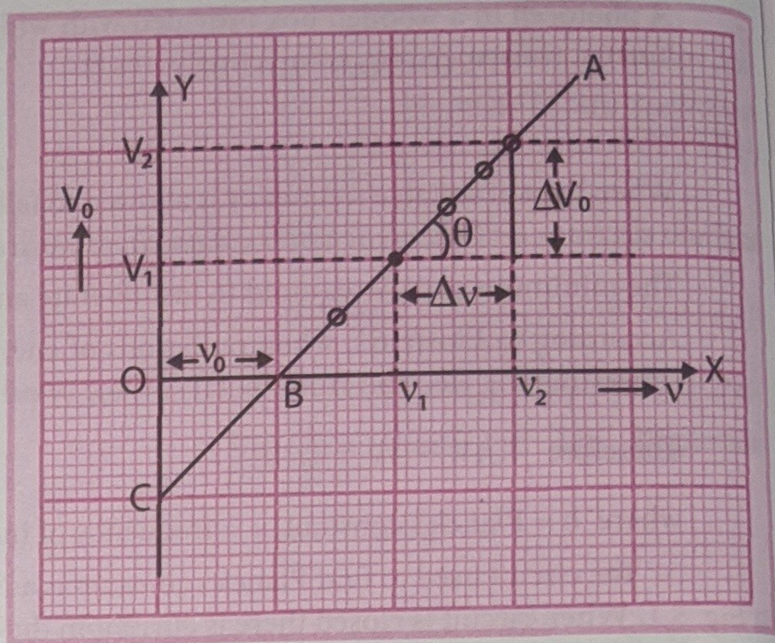

Fig. 5.2. Graph between stopping potential and frequency

Precautions:

(i) Lamp and scale arrangement should be adjusted properly.
(ii) No extraneous light should enter the photo cell.
(iii) The observation should be taken by changing negative anode potential in small steps of 0.05 volts (say).
(iv) Graph should be plotted carefully.
(v) The distance between photocell and source should be changed during experiment.
(vi) Photocell should not be exposed light for longer as the photo-sensitive part of photo cell will not give uniform number of electrons.