Experiment Number-8

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1. Aim: Determination of value of Planck's constant 'h'.

2. Apparatus:

Table 1: List of Equipments:

S.N.	Equipment	Range	Quantity
1	Digital Voltmeter (DVM) to measure the voltage across the L.E.D.s	0-20V	1
2	Digital milli ammeter to determine the current through L.E.D.s.	30mA	1
3.	Rheostat	0-1000ohm	1
4.	Resistor	1K	1
5.	L.E.D.s	Different colors	4
6.	Power Supply	0-10V	1
7.	A one way Key	NA	1

3. Theory:

Planck's constant (h), a physical constant was introduced by German physicist named Max Planck in 1900. The significance of Planck's constant is that 'quanta' (small packets of energy) can be determined by frequency of radiation and Planck's constant. It describes the behaviour of particle and waves at atomic level as well as the particle nature of light.

An LED is a two terminal semiconductor light source. In the unbiased condition a potential barrier is developed across the p-n junction of the LED. When we connect the LED to an external voltage in the forward biased direction, the height of potential barrier across the p-n junction is reduced. At a particular voltage the height of potential barrier becomes very low and the LED starts glowing, i.e., in the forward biased condition electrons crossing the junction are excited, and when they return to their normal state, energy is emitted. This particular voltage is called the **knee voltage** or the **threshold voltage**. Once the knee voltage is reached, the current may increase but the voltage does not change.

The light energy emitted during forward biasing is given as,

$$E = \frac{hc}{\lambda} \quad (1)$$

Where

c -velocity of light.

h -Planck's constant.

λ -wavelength of light.

If V is the forward voltage applied across the LED when it begins to emit light (the knee voltage), the energy given to electrons crossing the junction is,

$$E = eV \qquad (2)$$

Equating (1) and (2), we get

$$eV = \frac{hc}{\lambda} \qquad (3)$$

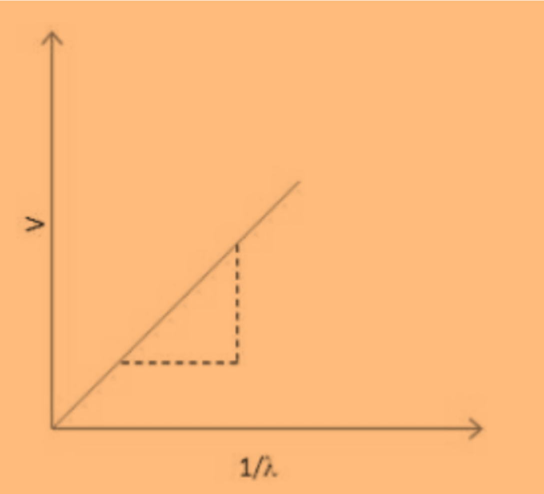
The knee voltage V can be measured for LED's with different values of λ (wavelength of light).

$$V = \frac{hc}{e}\left(\frac{1}{\lambda}\right) \qquad (4)$$

Now from equation (4), we see that the slope s of a graph of V on the vertical axis vs. $1/\lambda$ on the horizontal axis is

$$s = \frac{hc}{e} \qquad (5)$$

3.Graph:



To determine Planck's constant h, we take the slope s from our graph and calculate

h =e/c*s

using the known value

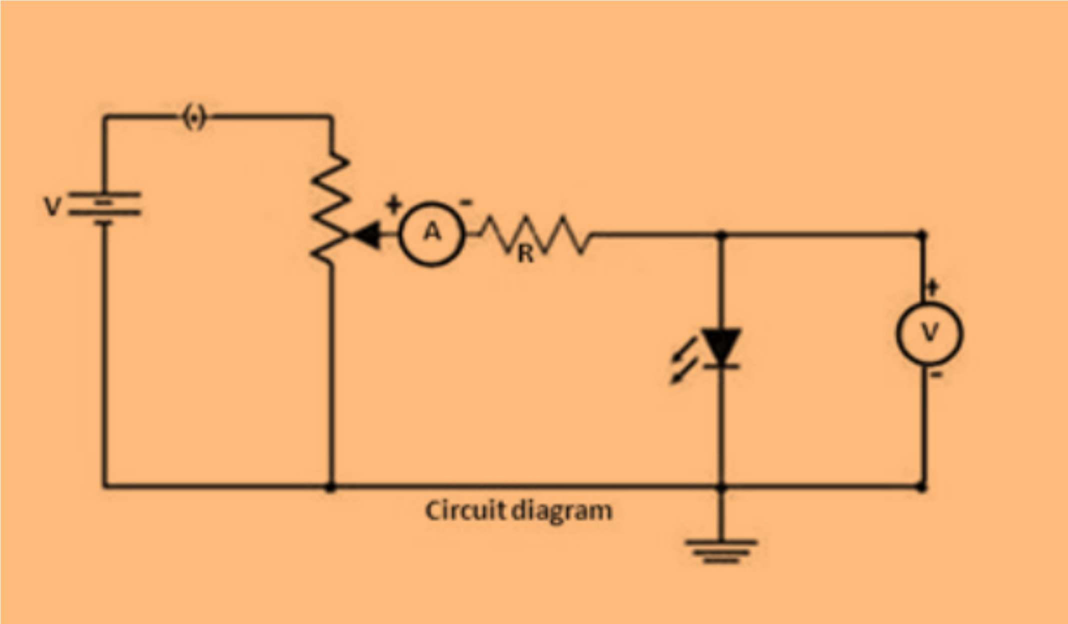
$$\frac{e}{c} = 5.33 \times 10^{-28} \frac{Cs}{m}$$

Alternatively, we can write equation (3) as

$$h = \frac{e}{c} \lambda V$$

calculate h for each LED, and take the average of results.

4. Circuit Diagram:



5. Formula Used:

$$E = h\upsilon \qquad (1)$$

$$E = eV \qquad (2)$$

Where $e = 1.6 \times 10^{-19}$ C

We then solve equation (1) for h and replace the E term with the equivalent of E in equation (2), as well as replace υ with:

$$\upsilon = c/\lambda$$

Where $c = 3 \times 10^8$ m/sec

We then get:

$$h = eV\lambda/c \qquad (3)$$

this equation can be rewritten as

$$V = hc/e\lambda \qquad (4)$$

It is this equation that we will use to determine Planck's constant.

Where h is Planck's Constant

υ is the frequency of light

6.Procedure:

1. Connections are made as shown in circuit diagram fig1.

2. Insert key to start the experiment.

3. Adjust the rheostat value till the LED starts glowing, or in the case of the IR diode, whose light is not visible, until the ammeter indicates that current has begun to increase.

4. Corresponding voltage across the LED is measured using a voltmeter, which is the knee voltage.

5. Repeat, by changing the LED and note down the corresponding knee voltage.

6. Using the formula given, find the value of the Planck's constant.

7.Procedure for Simulation:

1. After the connections are completed, click on 'Insert Key' button.

2. Click on the combo box under 'Select LED' button.

3. Click on the 'Rheostat Value' to adjust the value of rheostat.

4. Corresponding voltage across the LED is measured using a voltmeter, which is the knee voltage.

5. Repeat, by changing the LED and note down the corresponding knee voltage.

6. Calculate 'h' using equation

$$h = \frac{e\lambda V}{c}$$

7. The wave length of infrared LED is calculated by using equation,

Lamda = hc/ev

8. Observation Table:

Colour of LED	Wavelength (λ) (Nm)	Knee Voltage (V)	λV	$h = \frac{eV\lambda}{c}$
Blue.	475.	2.58.	0.000000 -1225	6.536×10^{-34}

8. Result/Output/Writing Summary:

The values of c = (3×10^{8} m/s) and e = (1.6×10^{-19} C) and determine the value of Planck's constant h.

Standard value of Planck's constant' h' is = 6.63×10^{-34} Js

The value of Planck's constant 'h'= 6.536×10^{-34} Js

9. Conclusion: Our experimental value of Planck's constant was well within the limits set by experimental uncertainty.

Learning outcomes (What I have learnt):

1. Calculate the value of Planck Constant and working of LEDs.
2. Set up and conduct present experiment with minimum error.
3. Application of LEDs .