Expt Viva

Planck's Constant Experiment Excellent 15 Viva Questions

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Planck's Constant Viva Questions:

Planck's Constant using LED

[determination of Planck's constant by using light-emitting diodes (LEDs)]

APPARATUS: Planck's constant kit, wires, graph paper, and 3-4 LEDs.

FORMULA USED: Planck's constant is $h = eV/v$, where e is an electronic charge, V is voltage reading in voltmeter, v is the frequency of particular LED color.

THEORY: The energy of a photon is given by the equation:

$$E = h\,v \qquad (1)$$

Where E is the energy of a photon, v is its frequency, and (h) is Planck's constant.

CASE 1: In the case of the photoelectric effect:

1. An electron is emitted from the metal only if the energy of the incident photon is greater than the work function of the metal.
2. These electrons can be attracted by the anode in a circuit and as a result of a current, you can observe with respect to the incident radiations (color).
3. If you need to measure the voltage difference, you can use resistance (the choice is open) in the circuit.
4. This voltage will be corresponding to the particular incident radiation energy.
5. If you need to know any other parameters, you can use this information (the current, the voltage, the color of incident radiation means the wavelength or frequency, so you can find the E=hv of the incident photon).

CASE 2. In the case of LEDs, the opposite of the above-mentioned working is true.

1. Here, in LED, If an electron of sufficient electrical energy (eV) is passed across a material then a photon emits.
2. But remember, the meaning of passes the electron across a material here is a diode.
3. That has two types of semiconductors (n- and p-type) and a p-n junction. Near to the p-n junction, there is a specific region known as the depletion region.
4. These electrons start from the n-region and after crossing the barrier (depletion region) reach in the p-region where they recombine and as a result, photon emits.
5. But to understand it you have to understand the energy band concept, this explanation is given in the semiconductor laser topic.

Please note that all materials don't show the photoelectric effect and emission of radiation like in LED. For LED we use Ga As the material that shows the optical properties when electron-hole recombination takes place.

If you got the flavor of the second case then it will be clear that you need forward biasing for this purpose. When you providing a sufficient voltage to the electron to cross the barrier only then it recombines with holes. And only then you can see the photons means that light.

So initially you can not see the light when you provide potential to the LED. But when you reach the threshold value of voltage where the electron is able to cross the junction then only you see the light. This value of potential you know is known as stopping potential.

Now the point is clear, also the emitted photon energy (hv) will be the same as the electrical energy of the electron (eV). Because of this reason you use;

$$eV = h\,v$$

$$h = eV / v$$

This equation we will use to determine Planck's constant.

PROCEDURE:

1. Make the connection in the kit.
2. Take the current measurement of each LED by varying the voltage as given in the table.
3. Plot the curve on the graph paper between the frequency of color on X-axis and electrical energy on Y-axis for all LEDs.
4. The slope of the curve will give a measured value of Planck's constant.
5. Compare the measured value with standard value and check the percentage error.

OBSERVATIONS:

Sr. No.	LED Color	Voltage	Wavelength λ [nm]	Frequency (v) [Hz]	Energy [J] = eV
1	Blue		475		
2	Green		510		
3	Yellow		570		
4	Red		650		

As mentioned in the procedure plot a graph between the last two-column of the above table that is the frequency of the particular LED and energy (eV). Take the slope of this graph and this will be your measured value of Planck's constant. Now compare it with the standard value ($6.62607004 \times 10^{-34}$ m^2 kg / s) and explain the percentage error. Check your self that what can be the reasons for this percentage error.

What you can analysis?

From your observation, you can also analyze the stoping potential of all the LEDs. How? Just see you have taken readings for each LED, either that one when LED starts to glow or also after it with some intervals of potential. So you have a set of reading with potential and current for each LED. When you will plot it for every LED you will observe that every LED starts with a specific value of the potential.

This value of the potential is known as the stoping potential and by this way, you can analyze the stoping potential for each color LED. But to determine the Planck's constant you will need a graph that points explained above.

VIVA QUESTIONS

1. How Planck's constant is determined?

2. How it is different from Si/Ge diode?
3. How **LED** works?
4. In the **photoelectric effect**, a suitable frequency of photon falls on an electron in an atom and ejects the electron. In LED when electron-hole recombination takes place a photon emits. How do you see these two phenomena?

5. Why do you put equal two different energies like eV and hv, what is the condition for that?

6. Which material do we use an LED?

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7. How photons emitted from the LED and from which section of the LED?

8. How do you explain the working of LED by using the *energy band diagram* in forward biasing?

9. What happens when you provide the forward bias to the LED in terms of conduction band & valence band in the depletion region?

10. Why do not LED starts to glow immediately when you provide the forwarding bias to that?

11. Explain the concept of stopping potential in semiconductor diode V-I Characteristics?

12. Why does Blue color LED stopping potential is greater than the Red color LED?

13. Can we achieve the population inversion process in LED too? if yes what is the condition for that? if no then why?

14. What symbol do we use for the Light Emitting Diode?

15. What information do we get from the Planck's Constant, and how one can say that radiation is in discrete form of energy?

Sources/Information Required to Explain/Understand the Experiment :

1. Working of a p-n Junction diode

2. Depletion region Concept/Idea along with potential barrier for Si/Ge

3. Semiconductor Material name that shows the optical property

4. Mainly energy band diagram of p-n junction diode and how electron transit from n to p side in depletion region in case of forward biasing.

5. The basic idea of electrical and radiation energy so can understand why they keep equal two different energy.

QUIZ

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1. Why do not LED starts to glow immediately when you provide biasing to that?

- **Due to the barrier potential of the depletion region**
- **Due to the barrier height of the p- region**
- **Due to the barrier height of the n- region**

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