# Physics Unit 3 and 4: Investigation

# Experimental determination of Planck’s constant using the threshold voltage of LEDs

1. Starting with equations from the Formulae and Data Booklet, derive that the relationship between the threshold voltage at which an LED turns on () and the wavelength of light produced by an LED () is . (3 marks)

3 starting equations, 1

equates energy, 1

correct derivation, 1

1. Describe a suitable method for safely varying the voltage applied to the LED and recording this voltage. A basic circuit diagram should be included in your answer. (4 marks)

Circuit diagram (no need for “proper” symbols) that:

* Would power an LED 1
* Has voltmeter/multimeter in parallel with LED 1

Describes a method that:

* Would vary the voltage of the LED 1
* Is likely to have a low risk of damaging the LED by staying under 3V (e.g. uses suitable resistance in series in the circuit diagram or describes this concern in the procedure). 1

1. Describe a significant source of uncertainty for either the LED wavelength or the threshold voltage in your experiment. Include an estimation of the absolute uncertainty this adds to the data. (2 marks)

Suitable uncertainty 1

Suitable justification 1

|  |  |
| --- | --- |
| LED | manufacturer data |
| Threshold voltage | hand drawn line of best fit for LED V-I curve/extrapolating intercept |

Only 1 mark max if choosing ±0.5 smallest division

The second-hand data in the table below is to be used to answer questions 4 and 5.

|  |  |  |  |
| --- | --- | --- | --- |
| LED Colour | Wavelength (nm) | Threshold Voltage (V) | Voltage Uncertainty (V) |
| Red | 635 | 1.58 | 0.16 |
| Orange | 623 | 1.73 | 0.18 |
| Yellow | 585 | 1.81 | 0.18 |
| Green | 525 | 2.44 | 0.24 |
| Blue | 470 | 2.55 | 0.26 or 0.25 |

1. Based on the combination of factors affecting the threshold voltage, it is suitable to approximate the uncertainty of the threshold voltage as . Fill in the “Voltage Uncertainty” column of the second-hand data. (2 marks)

All data is 10% of the measured voltage 1

All data is to **max** 2 sig figs 1

1. On the grid paper on the next page, produce a graph that can confirm the relationship between threshold voltage and LED wavelength given in question 1. Your choice of axes should produce a linear graph. Include error bars for the threshold voltage. (5 marks)

against 1

Suitable scale 1

Correctly sized error bars 1

Line of best fit within error bars 1

Axes labelled with correct units 1

1. Calculate the gradient of the line of bets fit. Include units. (3 marks)

Calculation resulting in accurate value\* 1

Clear use of graph to obtain data (not table data) 1

Correct units based on axes (or derived from formula) 1

\*Ideal answer between 1100 and 2000 V nm depending whether 0,0 treated as the intercept

1. Use the gradient to determine the value of Planck’s constant. (3 marks)

1

Converts wavelength to m (or has already done so on graph) 1

Calculates h 1

1. Calculate the percentage difference between your determination of Planck’s constant and the currently accepted value. (2 marks)

Clear setting out of % difference **formula** 1

Suitable values used to determine % difference 1

1. An organisation claims they have developed the world’s first purple LED and that it can be powered using a AA battery (1.5 V). Comment on the accuracy of their claim in relation to the findings of this investigation. (3 marks)

Describes discrepancy between likely wavelength and threshold voltage based on formula/graph against organisation claim 1-2

States the claim is not accurate 1