

Photon energy, work function and matter waves

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

Can a few LEDs and a voltmeter give you Planck's constant? An LED emits photons of energy about eV when it starts to glow, so its turn-on voltage depends on the colour. You will plot the voltage against $1/\lambda$ and find h from the gradient.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB E.2

Aim

To estimate Planck's constant from the minimum voltage at which LEDs of different colours begin to glow.

Equipment

- five LEDs of known wavelengths (about 630, 590, 525, 470 and 405 nm)
- 3 V supply (two 1.5 V cells), a 10 k Ω variable resistor used as a potential divider, and a 470 Ω protective resistor
- digital voltmeter
- short black card tube and a darkened room
- connecting leads

Safety

Safety

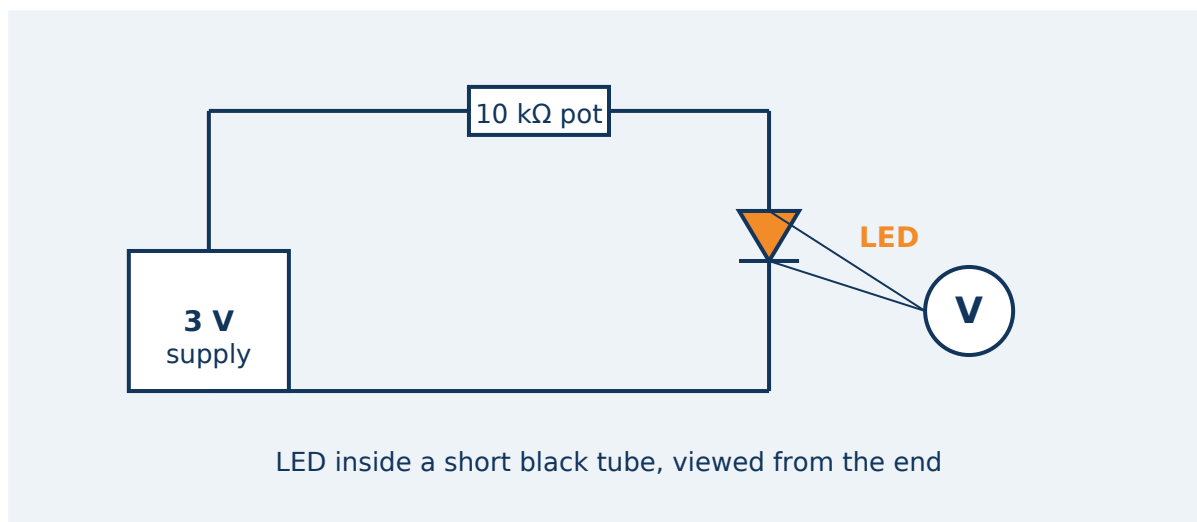
Never connect an LED without the protective resistor, and never look straight into the violet LED because it emits near-ultraviolet light. Use only the 3 V supply. Keep the cells away from metal objects that could short them.

Method

1. Connect the first LED, with the 470 Ω resistor in series, across the output of the potential divider, with the voltmeter in parallel with the LED.
2. Look into the end of the tube in the dark. Start at 0 V and raise the voltage slowly until the LED is just visibly glowing.
3. Record the voltage at that point as the turn-on voltage. Repeat three times and take the

mean.

4. Repeat for each of the other four LEDs.
5. Calculate $1/\lambda$ for each LED in units of 10^6 m^{-1} .



The turn-on voltage is read when the LED first glows in the dark tube.

Results

Mean turn-on voltages:

Colour	λ / nm	$1/\lambda / 10^6 \text{ m}^{-1}$	Turn-on voltage V / V
red	630	1.59	1.90
amber	590	1.69	2.03
green	525	1.90	2.29
blue	470	2.13	2.57
violet	405	2.47	2.99

Analysis questions

Question 1 Plotting

Plot V on the vertical axis against $1/\lambda$ on the horizontal axis and draw the line of best fit.

Question 2 Gradient

Determine the gradient of the line in V per 10^6 m^{-1} .

Question 3 Planck's constant

Use $eV = hc/\lambda$ to show that the gradient is hc/e , and calculate h .

Question 4 Comparison

Compare your value with the accepted value $6.63 \times 10^{-34} \text{ J s}$ as a percentage difference.

Question 5 The intercept

The best-fit line does not pass through the origin. Suggest a reason and give the intercept.

Question 6 Evaluation

Identify the main source of uncertainty and suggest two improvements.