

A Level Physics A

H556/02 Exploring physics

Question Set 17

- 1 (a) An approximate value of the Planck constant h can be determined in the laboratory using light-emitting diodes (LEDs). An LED suddenly starts to conduct and emit monochromatic light when the potential difference across an LED exceeds a minimum value V_0 . The potential difference V_0 and the wavelength λ of the emitted light are related by the equation

$$V_0 = \left(\frac{hc}{e}\right) \times \frac{1}{\lambda}$$

where e is the elementary charge and c is the speed of light in a vacuum.

Fig. 20.1 shows some data points plotted by a student on a V_0 against $\frac{1}{\lambda}$ graph for five different LEDs.

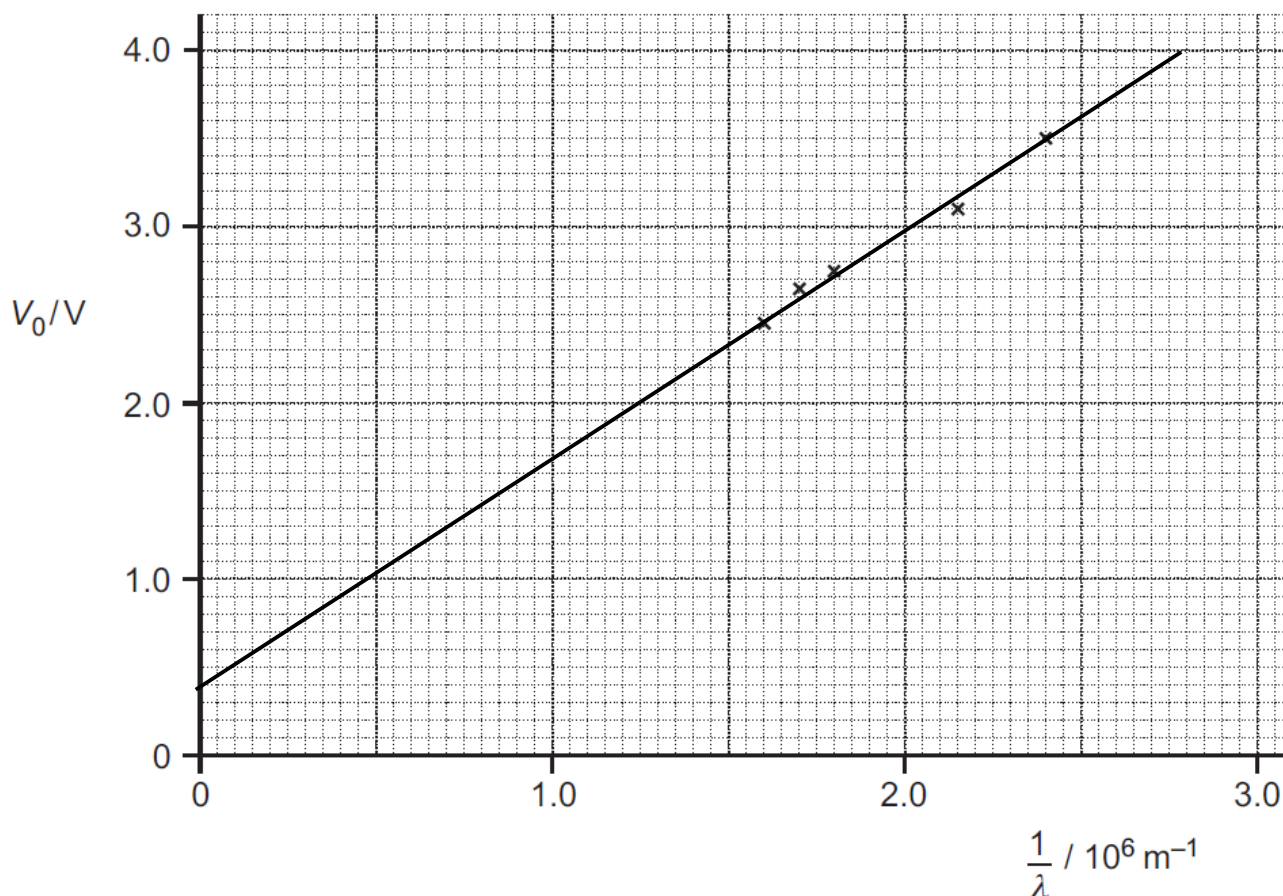


Fig. 20.1

The potential difference across each LED was measured using a digital voltmeter with divisions $\pm 0.01 \text{ V}$. The values for the wavelengths are accurate and were provided by the manufacturer of the LEDs.

The value of V_0 was determined by directly observing the state of the LED in the **brightly** lit laboratory.

- (i) Draw the straight line of best fit on Fig 20.1 and determine the gradient of the line.

gradient = $\frac{4 - 0.4}{2.8 \times 10^6} = 1.3 \times 10^{-6} \text{ V m} [2]$

- (ii) Use your answer in (i) and the equation on the page above to determine a value for h to 2 significant figures. Show your working.

$$\text{gradient} = \frac{hc}{e} \Rightarrow h = \frac{e \times 1.3 \times 10^{-6}}{2 \times 10^2} = 6.9 \times 10^{-34} \quad h = \dots\dots\dots 6.9 \times 10^{-34} \text{ Js [3]}$$

- (iii) Calculate the percentage difference between your value in (ii) and the accepted value of the Planck constant.

$$\frac{6.9 \times 10^{-34} - 6.63 \times 10^{-34}}{6.63 \times 10^{-34}} \times 100 = 4.1\% \text{ difference} = \dots\dots\dots 4.1\% \text{ [1]}$$

- (iv) Identify the two types of errors shown by the data in Fig. 20.1 and suggest how you could have refined the experiment to reduce or eliminate these errors. [4]

- Random error: the points are spread out on the line. Reduce by taking multiple readings and finding an average.
- Systematic error: non-zero y-intercept. Reduce by undertaking experiment in a dark room.

(b) Fig. 20.2 shows a gold-leaf electroscope with a clean zinc plate.

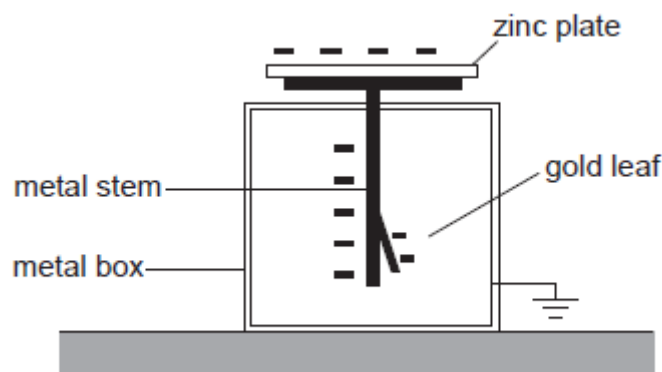


Fig. 20.2

The zinc plate, metal stem and the gold-leaf are given a negative charge by briefly connecting the zinc plate to the negative electrode of a high-voltage supply.

The gold leaf is fully diverged.

The position of the leaf is not affected by intense white light from a table lamp incident on the zinc plate. The gold leaf collapses very quickly when low-intensity ultraviolet radiation from a mercury lamp is incident on the zinc plate.

Explain these observations in terms of photons.

- There are one-to-one interactions between the photons + electrons
- Visible light photons have an $E <$ work function of zinc so no electrons are emitted.
- UV photons have an $E >$ work function of zinc so emit electrons from zinc
- This removes electrons, leading to the collapse of the leaf.

[4]

Total Marks for Question Set 17: 14

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