Oxford Cambridge and RSA

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.

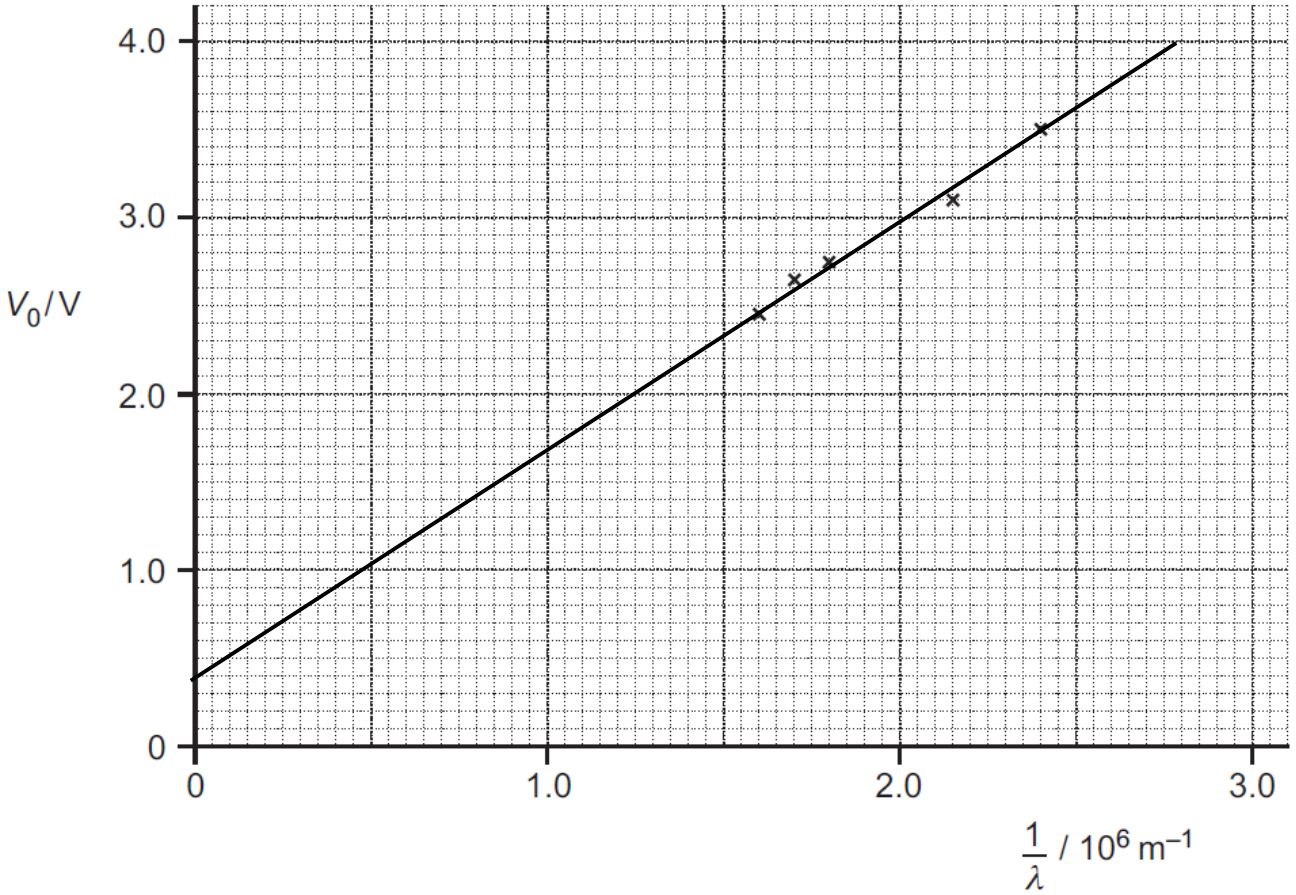

Fig. 20.1

The potential difference across each LED was measured using a digital voltmeter with divisions ± 0.01 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 = 1.3×10^{-6} V m **[2]**

gradient $= \frac{4 - 0.4}{2.8 \times 10^6} = 1.3 \times 10^{-6}$

(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.

gradient = $\frac{hc}{e}$ $\Rightarrow$ $h = \frac{e \times 1.3 \times 10^{-6}}{3 \times 10^{8}} = 6.9 \times 10^{-34}$

h = ... 6.9×10^{-34} ..... J s **[3]**

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

$\frac{6.9 \times 10^{-34} - 6.63 \times 10^{-34}}{6.63 \times 10^{-34}} \times 100 = 4.1\%$ difference = ... 4.1 ..... % **[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.

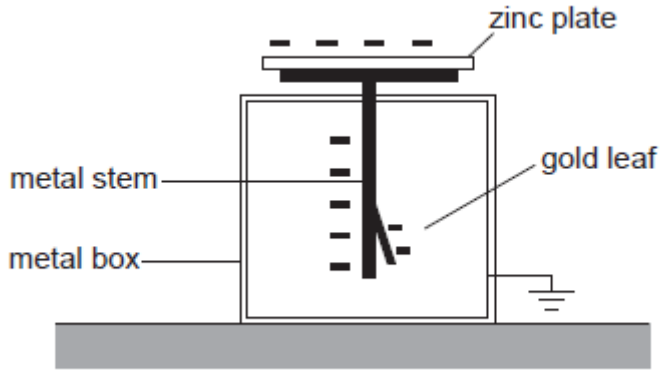

Fig. 20.2

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