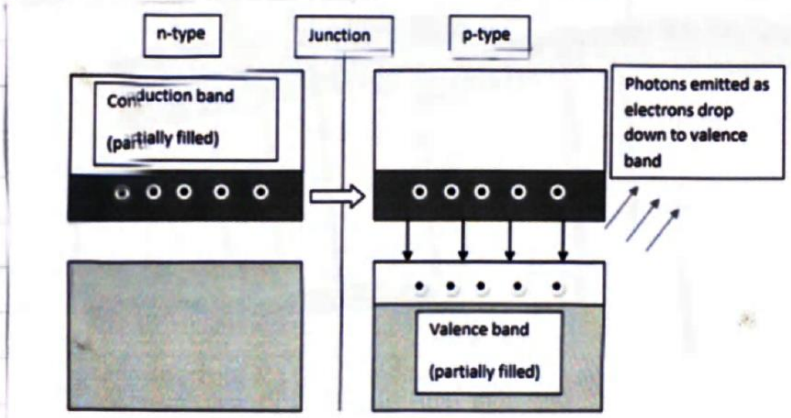
# Candidate 3 evidence (Switch on Voltage)

## Switch on Voltage of LEDs

This investigation is to see if the LED frequency affects the switch on voltage across the LED.

The switch on voltage is the minimum voltage across the LED that lights the LED.
An LED is a semiconductor device made from p-type and n-type semiconductor.
The diagram below is from a book about semiconductors and shows the structure of an LED.




When an electron falls from the conduction band to the valence band a photon is emitted. The greater the band gap between the conduction band and the valence band then the more energy the emitted photons will have. The energy of a photon is related to its frequency $E = hf$.

I set up the LED investigation board and selected a coloured LED using a switch.
A voltmeter was connected across the LED

to measure the switch on voltage. The voltage to the LED was increased until the LED started to produce light. I repeated for different colours of LED. The wavelengths of the LEDs were provided on the instruction sheet.

Results from the experiment are in the first table.

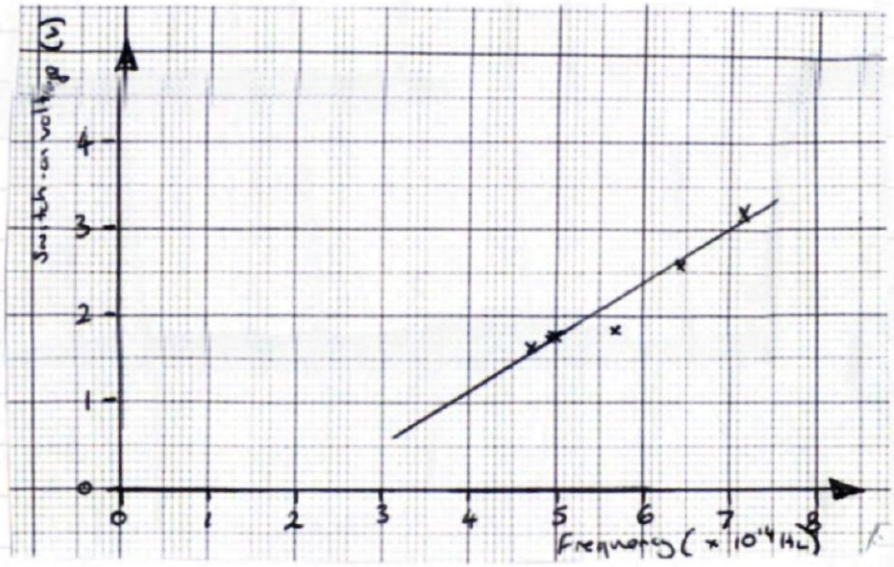
| Colour | Wavelength | Switch on Voltage |
|---|---|---|
| red | 635nm | 1.65V |
| orange | 607nm | 1.73V |
| yellow | 595nm | 1.77V |
| green | 527nm | 1.84V |
| blue | 469nm | 2.61V |
| violet | 417nm | 3.20V |

the scale reading uncertainty in the voltmeter was ±0.01V

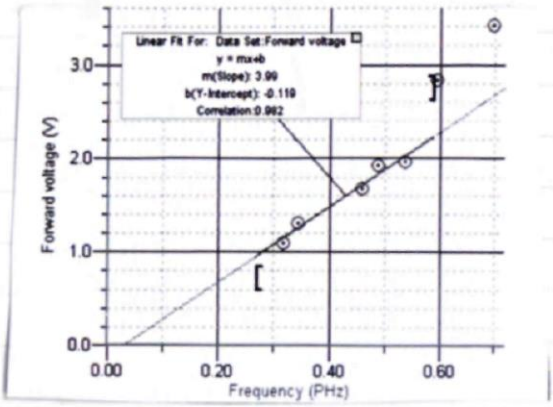
In the second table I used the equation $v = f\lambda$ to calculate the frequency of the coloured LEDs

| Frequency | Switch on voltage |
|---|---|
| $4.72 \times 10^{14}$ Hz | ~~1.65V~~ 1.65V |
| $4.94 \times 10^{14}$ Hz | ~~1.73V~~ 1.73V |
| $5.04 \times 10^{14}$ Hz | ~~1.77V~~ 1.77V |
| $5.69 \times 10^{14}$ Hz | ~~1.84V~~ 1.84V |
| $6.40 \times 10^{14}$ Hz | ~~2.61V~~ 2.61V |
| $7.19 \times 10^{14}$ Hz | 3.20V |

Graph




From a SSERC Bulletin on a website (1) I found the graph below that shows the same shape as mine.



I can conclude that the switch on voltage of an LED is affected by the frequency of light emitted.

The SSERC experiment used the graph to calculate a value for Plank's constant.

The gradient of the graph is equal to $\frac{h}{e}$

The gradient of my line is $6.24 \times 10^{-15}$ so my results give me a value of $1 \times 10^{-33}$ Js for Plank's constant. The real value is $6.63 \times 10^{-34}$ Js.

If I had more time I would have repeated the readings for switch on voltage a few times and ~~for~~ found an average for each colour. It was difficult to judge exactly when on LED started to emit light.

(1) https://www.mrsphysics.co.uk/higher/wp-content/uploads/2018/02/13-14_Plancks_Constant_with_LEDs.pdf (June 2018)