Coke Can Quantum Effects

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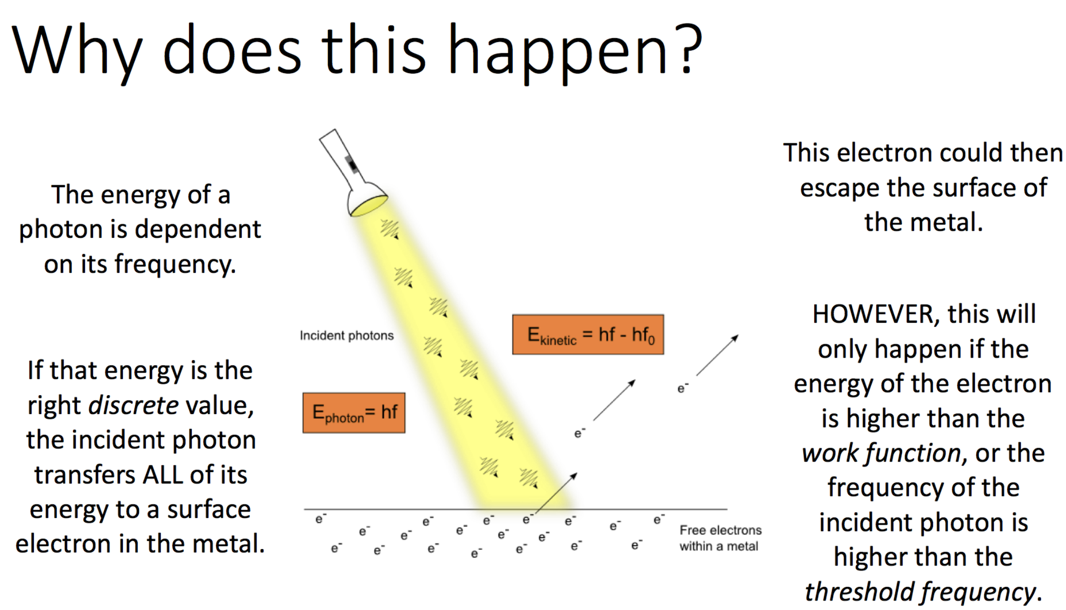
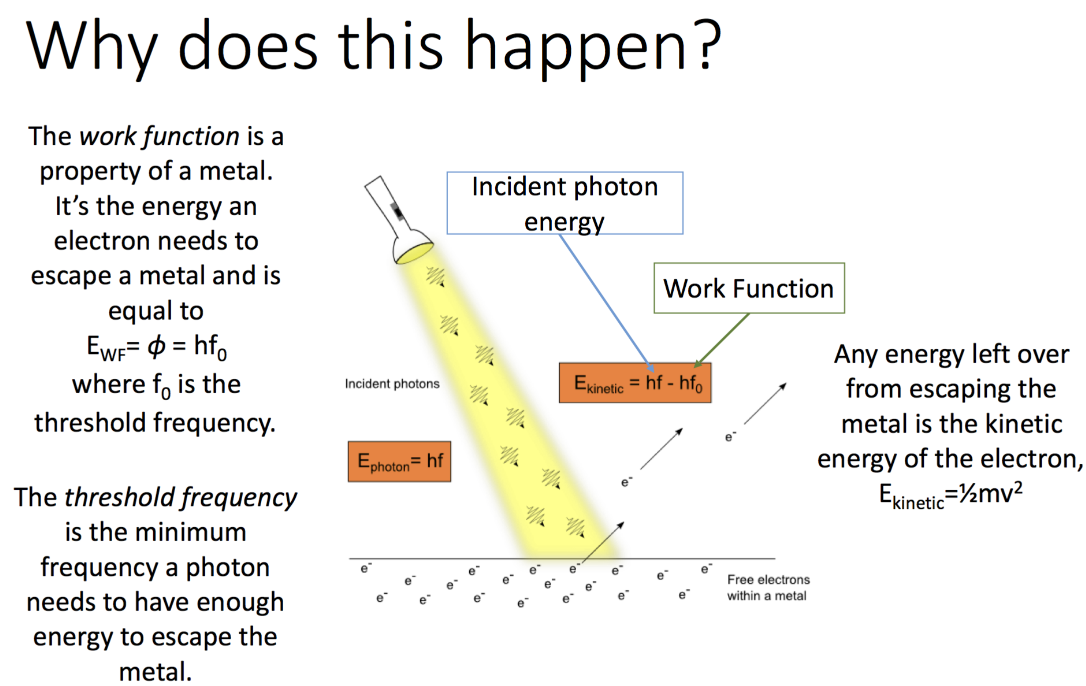
1 Introduction

The aim of this task was to be able to demonstrate the photoelectric effect with the use of household objects. This would show educators that they're able to do this experiment with a low budget. Through use of second hand objects obtained through colleagues, the only purchased object of this experiment was the UV-C light source, which can be bough online for £5 - £20. This project was part of an outrech summer placement.

1.1 The theory of the photoelectric effect.

When light sources of the right frequency are shone on particular types of metal, an electric current may be detected. This is because a photon has a discrete value of energy, dependent on its frequency. When the energy of an incident photon is the right quantity, it transfers its energy to an electron that is close to the metal surface. For the electron, this gain in energy means it can escape the metal surface. If it has gained enough energy the electron can travel after its escape, creating an electric current, as shown in Figure 1.1.





1.2 The setup of the experiment.

The effect can be shown using a polystyrene cup, tape, an aluminium can, copper wire, sandpaper, a balloon, long pieces of tinsel and a UV-C light wand source of wavelength 253.7nm constructed as in Figure 1.

1.3 Troubleshooting the experiment.

One problem stalled the completion of this demonstration as the photoelectric effect would not originally work. There were a few explored possibilities of the cause of this failure. The aluminium may have oxidised or may still have a layer preventing the UV rays freeing the electrons. To combat this the paint layer was sanded off one side of the can, then before each attempt, this section was lightly re-sanded to remove any new oxidisation. The UV-C source may not be the wavelength stated in the manufacturing booklet, therefore the threshold frequency may not have been reached. In theory, the UV-C light source would cause the photoelectric effect for metals with a work function lower than

$$E_{UV} = \frac{hc}{\lambda} = \frac{6.64 \cdot 10^{-34} * 3 \cdot 10^{8}}{253.7 \cdot 10^{-9}} = 4.89eV \tag{1}$$

where E_{UV} is the energy of the photons of the UV source, h is Planck's constant, c is the speed of light in a vacuum, and λ is the wavelength of the UV source. Therefore, metals with a lower work function than this could be used. The material that the 'aluminium' can is made out of may be an alloy with a higher work function than expected. Instead of the can, other objects were used including; an aluminium slab, aluminium food foil sheet, a foil cake tin and a takeaway food container, but these also did not work. The photoelectric effect may have been happening so slowly that it's not visibly discharging. The solution in the end came from the way the electric charge was being created. The PVC tube being used would take the

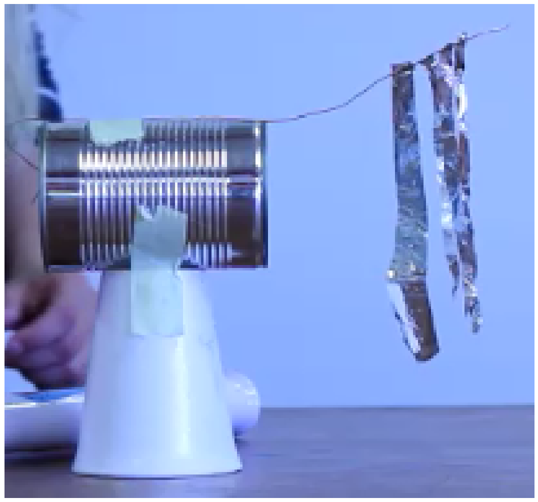


Figure 1: Photograph of the setup of the experiment.

electrons away from the setup, not add them on. When an amber rod was used instead, the photoelectric effect took place as electrons were added to the setup as intended.