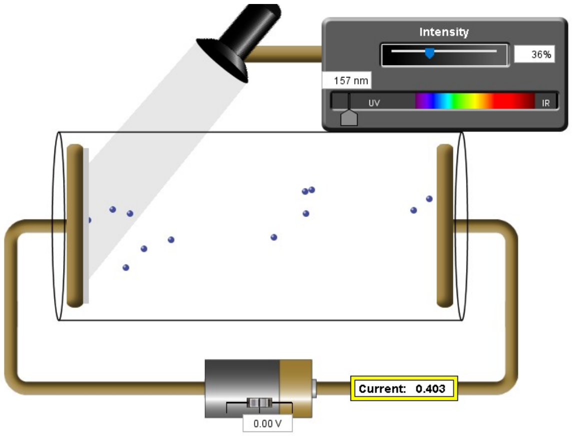
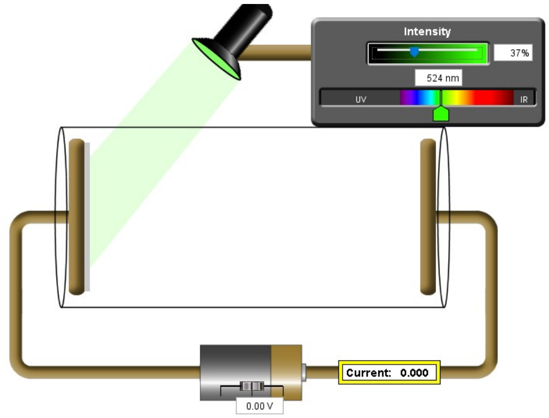
Photoelectric Effect

Observations

When light of a particular frequency is incident upon a metal plate, electrons are released from the surface straight away. Increasing the intensity increases the number of electrons emitted. If the frequency of the light is lowered, no electrons are emitted at all. Increasing the intensity and giving it more time does nothing, no electrons are emitted.





If Light was a Wave…

Increasing the intensity would increase the energy of the light. The energy from the light would be evenly spread over the metal and each electron would be given a small amount of energy. Eventually the electron would have enough energy to be removed from the metal.

Photon

Max Planck had the idea that light could be released in 'chunks' or packets of energy. Einstein named these wave-packets **photons**. The energy carried by a photon is given by the equation:

$$\boxed{E = hf}$$

Since $c = f\lambda$ we can also write this as: $\boxed{E = \frac{hc}{\lambda}}$

Explaining the Photoelectric Effect

Einstein suggested that one photon collides with one electron in the metal, giving it enough energy to be removed from the metal and then fly off somewhere. Some of the energy of the photon is used to break the bonds holding the electron in the metal and the rest of the energy is used by the electron to move away (kinetic energy). He represented this with the equation: $\boxed{hf = \phi + E_K}$

hf represents the energy of the photon, ϕ is the work function and E_K is the kinetic energy.

Work Function, ϕ

The work function is the amount of energy the electron requires to be completely removed from the surface of the metal. This is the energy just to remove it, not to move away.

Threshold Frequency, f_0

The threshold frequency is the minimum frequency that would release an electron from the surface of a metal, any less and nothing will happen.

Since $hf = \phi + E_K$, the minimum frequency releases an electron that is not moving, so $E_K = 0$

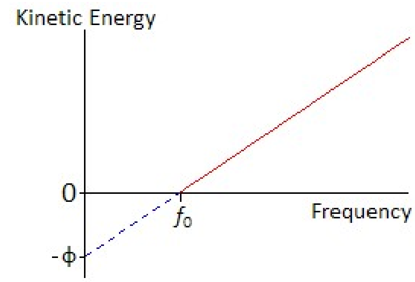
$hf_0 = \phi$ which can be rearranged to give: $\boxed{f_0 = \frac{\phi}{h}}$

Increasing the intensity increases the number of photons the light sources gives out each second.

If the photon has less energy than the work function an electron can not be removed. Increasing the intensity just sends out more photons, all of which would still not have enough energy to release an electron.

Graph

If we plot a graph of the kinetic energy of the electrons against frequency we get a graph that looks like this:



Start with $hf = \phi + E_K$ and transform into $y = mx + c$.

E_K is the y-axis and f is the x- axis.

This makes the equation become: $E_K = hf - \phi$

So the **gradient represents Planck's constant** and the **y-intercept represents (–) the work function**.