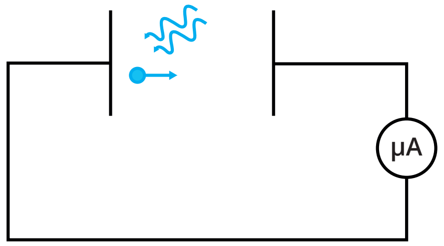
GCE Physics Unit 2.7 Photons

Photoelectric effect:

When light with enough energy hits the surface of a metal electrons are released.



Key observations from the experiment include:

- The current produced due to the electrons being released was unaffected by changing the brightness of the light.
- Changing the frequency of the light, changed the current.
- If the frequency of the light was too low, no electrons were released no matter how bright the light was.

This all meant that one packet of light interacted with one electron, proving that light behaved as photons.

The energy of the photons can be calculated using these equations;

$$E = hf = \frac{hc}{\lambda}$$

Where h = Plank constant = 6.63×10^{-34}Js

Equation:

By applying a potential difference to oppose the current in the above circuit, it is possible to measure the p.d. required to just stop the current. This is equivalent to the maximum kinetic energy of the released electrons.

$$E_{k\,max} = e\,V_{stop}$$

This can be used in the equation to calculate the work function, ϕ, of the metal. **The work function is the energy required to just release an electron.**

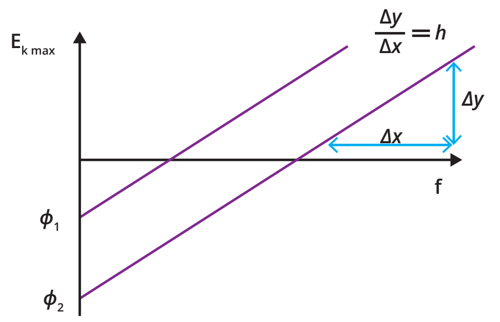
$$E_{k\,max} = hf - \phi$$

Comparing the equation $E_{k\,max} = hf - \phi$ to

$$y = mx + c$$

Predicts that a graph of $E_{k\,max}$ against f will be a **straight line with gradient = h and a negative intercept equivalent to ϕ.**

This graph shows the results for two different metals, note that they have the **same gradient** but **different intercepts**.



Electromagnetic spectrum:

It is important to recognise these values to predict which part of the spectrum is applicable to the experiment, both in the photoelectric effect and in absorption or emission.

Region	Typical wavelength /m	Typical energy /eV
Gamma ray	10^{-12}	10^{6}
X ray	10^{-10}	10^{4}
Ultraviolet	10^{-7}	10
Visible light	7×10^{-7} (Red) to 4×10^{-7} (Violet)	2.5
Infrared	10^{-5}	10^{-1}
Microwave	10^{-2}	10^{-4}
Radio	10^{2}	10^{-8}

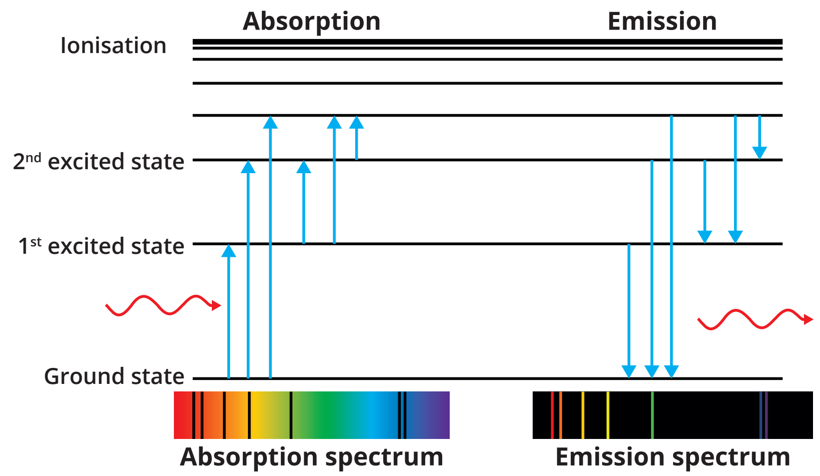
Note that the energy is given in electron volts, eV. Conversion between eV and Joules, J is often required.

1eV = 1.6×10^{-19}J

Absorption and emission:

In atoms there are specific energy levels that the electrons can move between. When they move from one level to another they can absorb or emit a photon. This photon will have an **energy, *hf*, equivalent to the difference in the energies** between the two energy levels.

These diagrams show some of the possible transitions



Absorption and emission spectra can be seen by directing the light through a diffraction grating.

Ionisation energy is the energy required to remove an electron from the ground state.

Electron diffraction:

When **electrons** are accelerated towards graphite crystals, a **diffraction pattern** is produced. This proves that electrons have wave like properties.

This means that waves and particles can behave in similar ways. Louis de Broglie predicted that you could calculate the **momentum of a wave**, or the **wavelength of a particle**, using this equation;

$$p = \frac{h}{\lambda}$$

$E_{k\,max}$ = maximum kinetic energy in J | f = frequency in Hz | λ = wavelength in m | ϕ = work function in J

p = momentum in kgms^{-1} | E = energy in J | eV = electron Volt = 1.6×10^{-19}J