

Photons

Particle nature of light: Light arrives in particles called photons

The energy of a photon is given by:

$$E = hf \quad h = 6.63 \times 10^{-34}$$

$$E = \frac{hc}{\lambda} \quad c = 3 \times 10^8 \text{ ms}^{-1}$$

$$c = f\lambda \rightarrow f = \frac{c}{\lambda}$$

sub instead of f to get

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

Quantum
Physics
Chapter 13

Base unit of h

$$h = \frac{E}{f} \quad E = \frac{1}{2}mv^2$$

$$\frac{\text{kg m}^2 \text{ s}^{-2}}{\text{s}^{-1}} = \text{kg m}^2 \text{ s}^{-1}$$

The electronvolt eV

Definition: energy acquired by an electron when it passes through a p.d. of 1 V

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$3.6 \times 10^{-19} \text{ J} = \frac{3.6 \times 10^{-19}}{1.6 \times 10^{-19}} = 2.3 \text{ eV}$$

$$5 \text{ eV} = 5 \times 1.6 \times 10^{-19} = 8 \times 10^{-19} \text{ J}$$

Why max KE

$$hf = \phi + KE_{\text{max}}$$

ϕ is the minimum amount of energy required for an electron to escape

Most electrons require more than the work function to escape the surface of the metal

The photoelectric effect

Occurs when a photon of sufficiently high frequency interacts with the surface of a metal and releases an electron

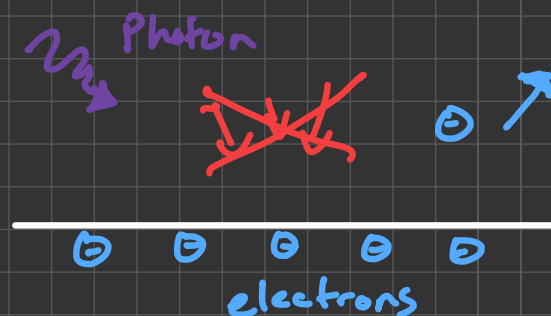
The emission occurs almost instantly whereas wave theory predicts that the emission would take time

The photoelectric effect is an experiment that proves that particulate nature of EM radiation

ϕ is the work function, the minimum amount of energy required to release an electron from the surface of metal.

f_0 is the threshold frequency, the minimum photon frequency required to release a photon from the surface of a metal.

$$E = hf \quad \phi = hf_0 \quad hf = \phi + KE_{\text{max}}$$



1. If the energy of the photon $>$ work function an electron will be emitted
2. If the energy of the photon $<$ work function. No electrons are emitted.
3. There is a one to one interaction between electrons and photons
i.e. if we use a lower energy photon we can never get more than 1 photon interacting with an electron and releasing it

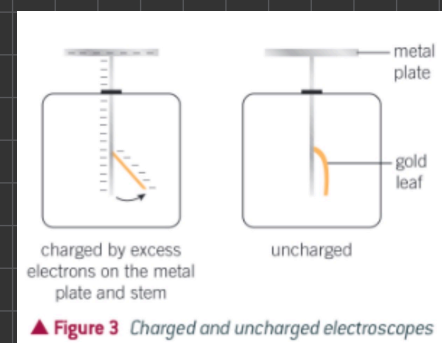
Gold leaf Electroscope

We charge a gold leaf electroscope with a plastic rod.

Charge is accumulated on the surface of the zinc plate and on the gold leaf

Due to electrostatic repulsion the gold leaf rises

Wave particle duality



Increasing the intensity will increase the number of photons emitted only if the frequency is greater than the threshold frequency

$$hf = \phi + KE_{\text{max}}$$

$$KE_{\text{max}} = hf - \phi$$

$$y = mx + c$$

$$c = -\phi$$

$$m = h$$

Electron diffraction

$$\lambda = \frac{h}{p} \text{ - momentum}$$

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

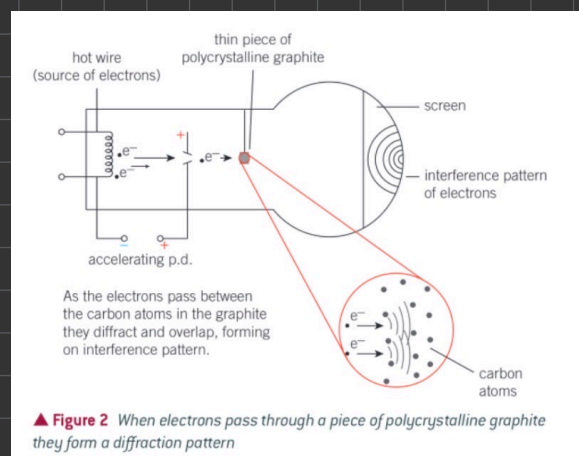


Figure 2 When electrons pass through a piece of polycrystalline graphite they form a diffraction pattern