Wave-Particle Duality

To know how to calculate the de Broglie wavelength and what is it
To be able to explain what electron diffraction shows us
To know what wave-particle duality is

De Broglie

In 1923 Louis de Broglie put forward the idea that 'all particles have a wave nature' meaning that particles can behave like waves.
This doesn't sound too far fetched after Einstein proved that a wave can behave like a particle.
De Broglie said that all particles could have a wavelength. A particle of mass, m, that is travelling at velocity, v, would have a wavelength given by:

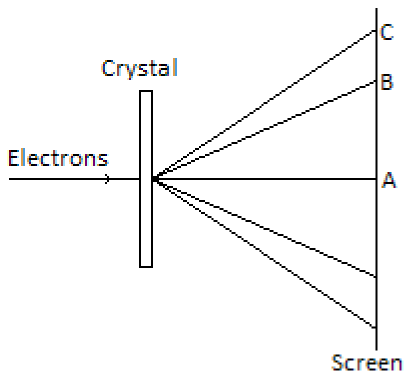
$\lambda = \frac{h}{mv}$ which is sometime written as $\lambda = \frac{h}{p}$ where p is momentum

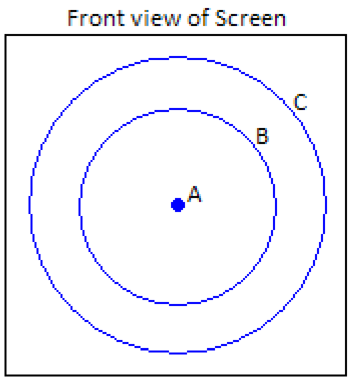
This wavelength is called the de Broglie wavelength. The modern view is that the de Broglie wavelength is linked to the probability of finding the particle at a certain point in space.

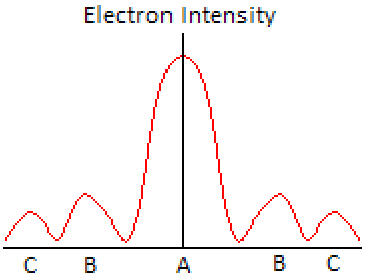
De Broglie wavelength is measured in metres, m

Electron Diffraction

Two years after de Broglie came up with his particle wavelengths and idea that electrons could diffract, Davisson and Germer proved this to happen.
They fired electrons into a crystal structure which acted as a diffraction grating. This produced areas of electrons and no electrons on the screen behind it, just like the pattern you get when light diffracts.







Electron Wavelength

We can calculate the de Broglie wavelength of an electron from the potential difference, V, that accelerated it.
Change in electric potential energy gained = eV

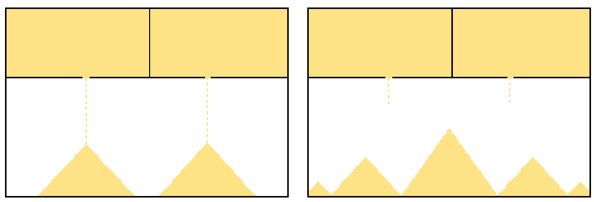
This is equal to the kinetic energy of the electron $$eV = \frac{1}{2}mv^2$$

The velocity is therefore given by: $$\sqrt{\frac{2eV}{m}} = v$$

We can substitute this into $\lambda = \frac{h}{mv}$ to get: $$\lambda = \frac{h}{\sqrt{2meV}}$$

Sand Analogy

If we compare a double slit electron diffraction to sand falling from containers we can see how crazy electron diffraction is. Imagine two holes about 30cm apart that sand is dropping from. We would expect to find a maximum amount of sand under each hole, right? This is not what we find! We find a maximum in between the two holes. The electrons are acting like a wave.



Wave-Particle Duality

Wave-particle duality means that waves sometimes behave like particles and particles sometimes behave like waves. Some examples of these are shown below:

Light as a Wave

Diffraction, interference, polarisation and refraction all prove that light is a wave and will be covered in Unit 2.

Light as a Particle

We have seen that the photoelectric effect shows that light can behave as a particle called a photon.

Electron as a Particle

The deflection by an electromagnetic field and collisions with other particles show its particle nature.

Electron as a Wave

Electron diffraction proves that a particle can show wave behaviour.