The Wavefunction

The **Schrodinger theory** assumes assumes that there is a wave associated with the electron. This wave is called the **wavefunction**, $\psi(x, t)$ and is a function of position x and time t.

The **wavefunction** is a function of time and position whose magnitude squared is related to the probability of finding a particle somewhere.

Max Born suggested that the **probability** that an electron will be found within a small volume ΔV near position x at time t is:
$P(x, t) = |\psi(x, t)|^2 \Delta V$

The theory only gives probabilities for finding an electron somewhere and does not pinpoint an electron at a particular point in space.

A travelling wave has the same $|\psi(x, t)|^2$ value and therefore has the same probability of detection at all points along its path, but this is not true for a standing wave.

A particle in an well approaches either side of the well, and a force reverses the electron's motion, which traps it. Inside the well the potential energy is zero $U(x) = 0$ and the electron behaves like a *standing wave* in a string with two fixed ends. (Topic 4 - Standing Waves)

A graph of $\psi(x)$ and $|\psi(x)|^2$ can be used to predict the probability of detecting the electron at some position along the x axis.

The Uncertainty Principle

The **Heisenberg uncertainty principle** applied to position and momentum states that it is not possible to measure simultaneously the position and momentum of a particle with indefinite precision. This represents a fundamental property of nature.

The uncertainty Δx in position and the uncertainty Δp in momentum are related by:

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

where h is Planck's constant.

Making momentum as accurate as possible makes position innacurate, whereas accuracy in position results in inaccuracy in momentum. In particular, if one is made zero, the other has to be infinite.

An uncertainty in position implies an uncertainty in the momentum.

The uncertainty principle also applies to measurements of energy and time.

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

Diffraction

A nuclear diameter can also be determined by measuring the diffraction of a beam of high-energy electrons or neutrons having a de Broglie wavelength of λ. If the wavelength is about the same as the nuclear diameter's, the neutrons will diffract around the nuclei. The nuclear barrier acts like a single-slit. A minimum will be formed at at angle θ to the original direction according to:

$$\sin\theta = \frac{\lambda}{D}$$

Be careful! D is the aperture of the diffracting object in this case. In previous topics, b was the aperture.

Electrons work well because they do not respond to the strong force inside the nucleus, probing the nuclear charge distribution. Neutrons work well because they are not affected by the Coulomb force, getting near the nucleus.