Excitation, Ionisation and Energy Levels

The Electronvolt, eV

The Joule is too big use on an atomic and nuclear scale so we will now use the electronvolt, represented by eV. One electronvolt is equal to the energy gained by an electron of charge $e$, when it is accelerated through a potential difference of 1 volt.

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

$$1 \text{ J} = 6.25 \times 10^{18} \text{ eV}$$

The Problem with Atoms

Rutherford’s nuclear model of the atom leaves us with a problem: a charged particle emits radiation when it accelerates. This would mean that the electrons would fall into the nucleus.

Bohr to the Rescue

Niels Bohr solved this problem by suggesting that the electrons could only orbit the nucleus in certain ‘allowed’ energy levels. He suggested that an electron may only transfer energy when it moves from one energy level to another. A change from one level to another is called a ‘transition’.

To move up and energy level the electron must gain the exact amount of energy to make the transition. It can do this by another electron colliding with it or by absorbing a photon of the exact energy.

When moving down a level the electron must lose the exact amount of energy when making the transition. It releases this energy as a photon of energy equal to the energy it loses.

$$\Delta E = hf = E_1 - E_2$$

$E_1$ is the energy of the level the electron starts at and $E_2$ is the energy of the level the electron ends at.

Excitation

When an electron gains the exact amount of energy to move up one or more energy levels

De-excitation

When an electron gives out the exact amount of energy to move back down to its original energy level

Ionisation

An electron can gain enough energy to be completely removed from the atom. The ground state and the energy levels leading up to ionisation have negative values of energy, this is because they are compared to the ionisation level. Remember that energy must be given to the electrons to move up a level and is lost (or given out) when it moves down a level.

Line Spectra

Atoms of the same element have same energy levels. Each transition releases a photon with a set amount of energy meaning the frequency and wavelength are also set. The wavelength of light is responsible for colour it is. We can analyse the light by using a diffraction grating to separate light into the colours that makes it up, called its line spectra. Each element has its own line spectra like a barcode.

To the above right are the line spectra of Hydrogen and Helium. We can calculate the energy difference that created the colour. If we know the energy differences for each element we can work out which element is responsible for the light and hence deduce which elements are present.

We can see that there are 6 possible transitions in the diagram to the left, A to F. D has an energy difference of 1.9 eV or $3.04 \times 10^{-19}$ J which corresponds to a...
frequency of $4.59 \times 10^{14}$ Hz and a wavelength of 654 nm – red.