2.10.1 Energy levels and spectra

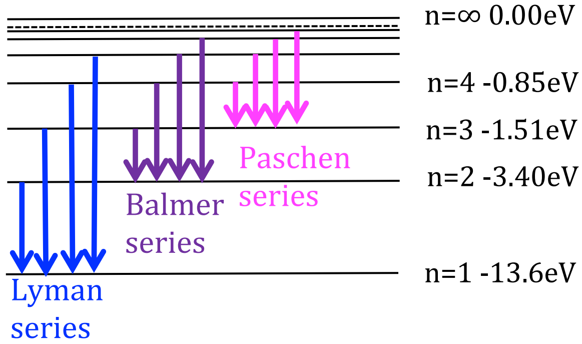
Atoms of different elements have different energy levels in which its electrons can reside. Electrons will occupy the lowest energy level (ground state) unless excited to higher energy levels. They can be excited to a higher energy level if they are hit by a fast-moving electron or if they absorb a photon. When electrons drop down from a higher level to the ground state, they emit a photon or a series of photons.

videos

Because atoms of different elements have different energy levels, the frequency of the photons that they absorb (during excitation) or emit (during de-excitation) will be different and a unique 'fingerprint' which identifies the particular atom.

As an example, the following diagram shows the energy levels in a hydrogen atom:

Hydrogen



The de-excitation of hydrogen produces a number of distinctive photon frequencies. The transitions to the ground state (called the Lyman series) produces photons in the ultraviolet part of the electromagnetic spectrum. Transitions down to n=2 (the Balmer series) produce photons in the visible part of the spectrum. Transitions down to n=3 (the Paschen series) produce photons in the infrared part of the spectrum.

(1)✏Why do the transitions to the ground state produce ultraviolet photons, whereas the transitions to n=2 produce visible light photons?

If we excite hydrogen atoms by bombarding them with fast moving electrons and observe the spectrum of photons emitted we will observe (in the visible part of the spectrum) characteristic frequencies corresponding with the Balmer series transitions. This is called a <u>line spectrum</u>.

This is what the line spectrum for hydrogen looks like.

You can observe a line spectrum for hydrogen by using a gas discharge tube containing hydrogen, and passing the light emitted through a prism or through a diffraction grating.

(2)✏The red line, on the left, represents the lowest energy transition in the Balmer series. What transition does this involve (in terms of n)?

The line spectrum in the photo (above) is called an emission spectrum, because it is light emitted by excited atoms.

We can also observe a line spectrum in the situation where white light (a continuous spectrum) is passed through a gas. Certain frequencies are absorbed by the atoms in the gas (corresponding to energy transitions) leaving dark lines. This is called an absorption spectrum and is used to identify elements in distant stars, the temperature of stars and their relative movement. This will be covered later in the course.