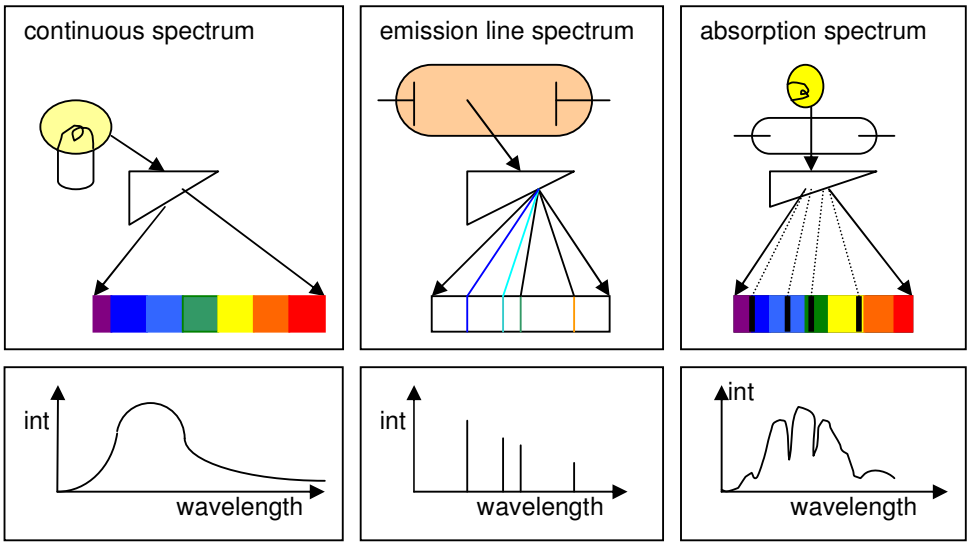
-this is called an **absorption line spectrum**.
-all three spectra are shown below, including intensity wavelength graphs.

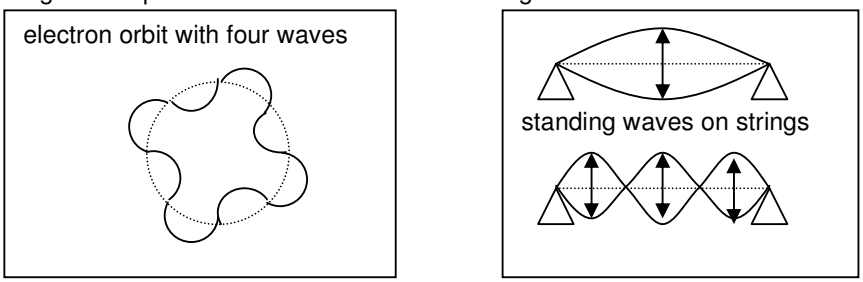


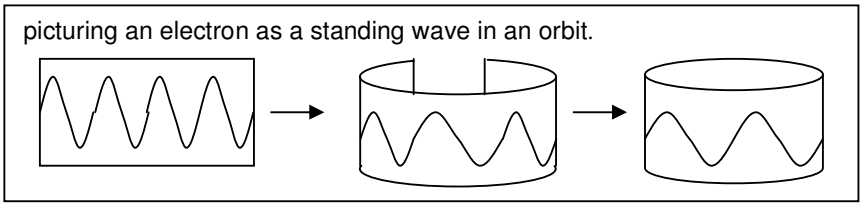
spectra as evidence for quanta

-the same element always gives the same emission line spectrum.
-this suggests that atoms can only have certain amounts of energy.
-in the case of the spectrum from hydrogen, the lines follow a geometrical progression, also suggesting that energy in atoms is quantized.

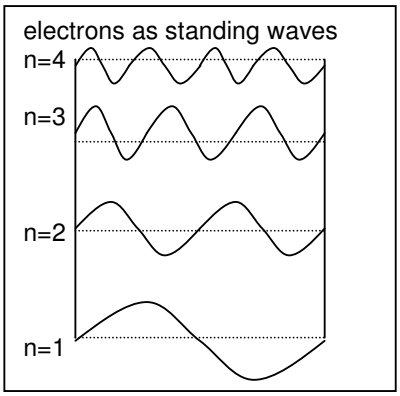
the Bohr model

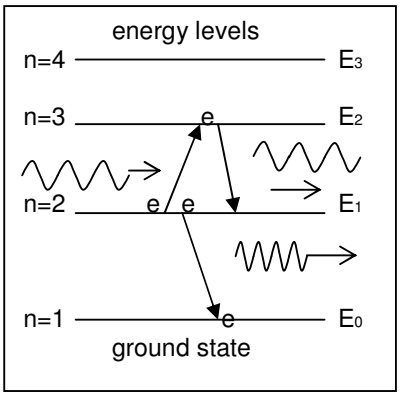
-in the **Bohr model** of the atom, there are two important postulates
-first, electrons can only exist in orbits where the angular momentum is an interger multiple of $h/2\pi$ which is written as η. h is Planck's constant.
-electrons can jump between orbits by absorbing or emitting radiation.
-normally a 'free' charge that accelerates will radiate its energy away.
-an electron in a circular orbit is accelerating so should lose energy.
-however a bound electron behaves differently to a free electron.
-the electron can be treated as a wave in an atom.
-if an integer of waves fit in an orbit, the electron becomes a standing wave.
-in standing waves, no energy is transported so none can be lost.
-a wave on a string is a standing wave, shown in the diagram below right.
-eg consider an electron as complete waves on an orbit.
-an ac signal shown on an oscilloscope is a good image.
-a metal ring when struck sets up standing waves, similar to that of a musical 'triangle'. The picture below left shows an orbiting electron of four waves.





-the diagram above left shows an electron in an orbit as a standing wave.
-this orbit shows the electron as four complete waves.
-as there needs to be an integer No. of waves, one wave is the simplest.
-the next simplest is two then three and so on.
-if the orbits are flattened out again, they can be shown as below left.





-the lowest orbit where n =1 is called the **ground state** with energy E_0.
-if the electron is in a higher orbit, it is called an **excited state**.
-an electron can jump to a higher state by absorbing a photon.
-it can only absorb a photon if the energy difference between states is equal to the photon's energy.
-eg an electron is in the second orbit E_1 and jumps to the third orbit E_2 by absorbing a photon.
-the energy of the photon E must be the difference in the two energy levels.

-thus $E = E_2 - E_1$.

-electrons can also jump to higher levels via collisions or high voltages.
-when an electron falls to a lower level, it emits a photon.
-an electron falls from the second level E_1 to the ground state E_0, the energy of the photon $E' = E_1 - E_0$.
-all the energy states of an electron in an atom are negative and take only certain values.
-the energy of a free electron is always positive and can have any value.
-this topic is dealt with in more detail later.

Key points

-in the Bohr model of the atom electrons can only exist with certain energies.
-electrons move between levels by absorbing or emitting radiation.

<u>limits of the Bohr model</u>

-the main limitation of the Bohr model is that it only works with one electron.
-this is fine for the hydrogen atom where there is only one atom.
-it can work for helium that has lost one of its two electrons (singly ionised).
-it can work for lithium that is doubly ionised and so on.