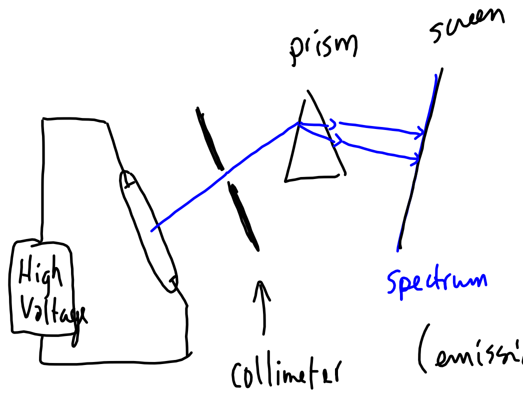
Experimental Arrangement: Line Emission Spectra from Atoms



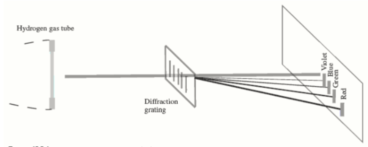


Figure 120-1 Measuring the spectrum of the hydrogen atom.

(emission line spectrum)

from the excited electrons falling back down to lower energy levels.

- discrete wavelengths / frequency / energy.
- unique to each element
- spectrum can be used to identify element.

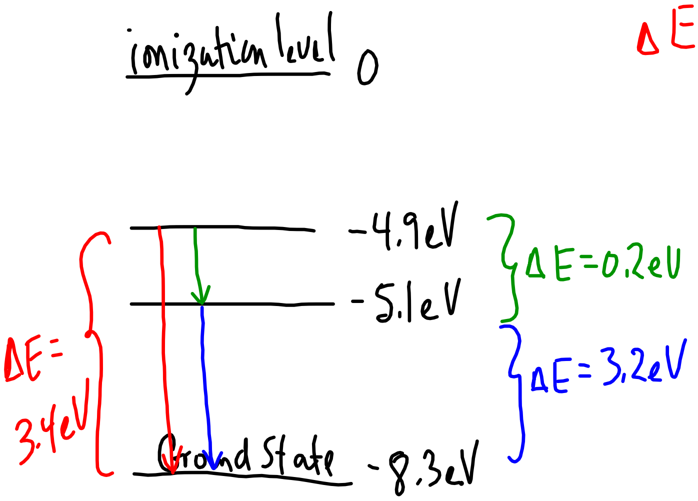
Evidence for the existence of atomic energy levels

- the evidence comes from line spectra for the elements.

- Vapour of the element emits light of discrete frequencies
- When the these frequencies of light are dispersed (by a prism / diffraction grating) then an emission line spectrum is produced.
- the discrete frequencies (f) correspond to discrete energy photons of energy ($E = hf$)
- the electrons in the atoms are emitting discrete energy photons
- the electrons in the atom must exist in discrete energy levels

Example

Electrons of energy 3.6eV are fired through the vapour of an element whose energy level diagram is shown below. Calculate the wavelengths of light emitted from the vapour.



$\Delta E = 3.4\,eV\left(\frac{1.6\times10^{-19}\,J}{eV}\right) = 5.4\times10^{-19}\,J$

$\Delta E = hf$ $\quad c = \lambda f$ $\quad f = \frac{c}{\lambda}$

$\Delta E = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{\Delta E}$

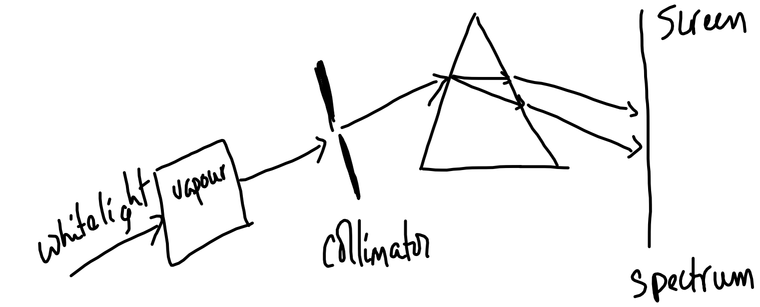
$\lambda = \frac{(6.63\times10^{-34}\,J\cdot s)(3.00\times10^{8}\,ms^{-1})}{5.44\times10^{-19}\,J}$

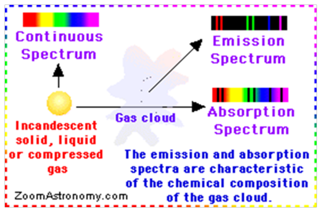
$\lambda = 3.7\times10^{-7}\,m$

(370nm)

(UV)

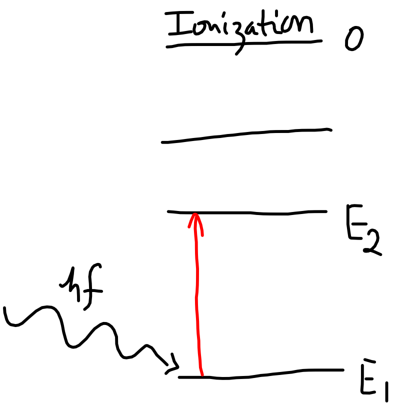
Experimental Arrangement for Line absorption Spectrum





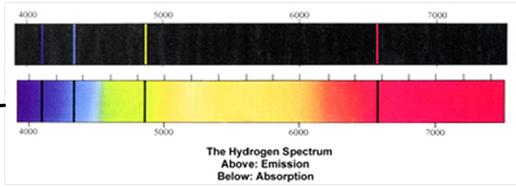
- the vapour absorbs discrete energy photons from white light which correspond to the energy required to move the electron to a higher energy level.
- the spectrum produced is continuous, but with those discrete energies or frequencies missing.
- called a line absorption spectrum

Process for the production of a line absorption spectrum

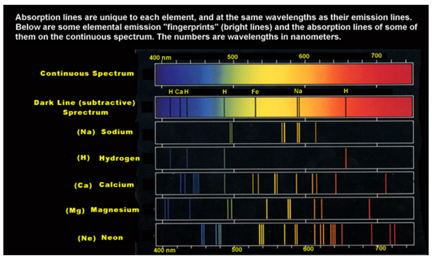


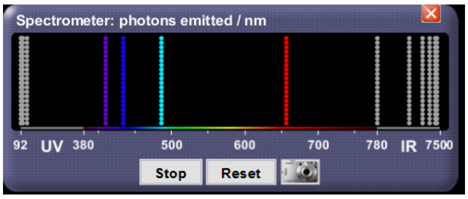
- An electron can absorb one photon only
- A photon can give all of its energy to the electron or none of it.
- only those photons corresponding to the energy of the various transitions can be absorbed.
- the emerging spectrum has those discrete energy photons missing from it.
- the excited electron returns to the ground state almost instantly (1 ns) so photon of the same energy will be emitted but in a random direction and will not be detected.

Comparison of Emission + Absorption Spectra

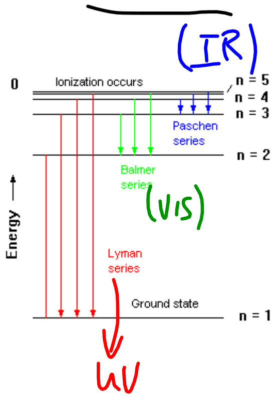


- electrons only exist in the excited state for about 1 ns
- absorption occurs when the electron is in the ground state.
- the absorption spectrum is really just a subset of the emission spectrum (same wavelengths, but fewer lines)

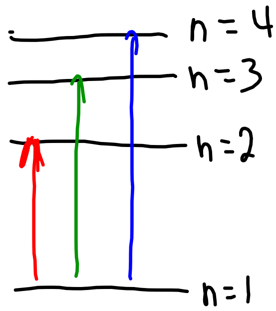




Emission



Absorption



Composition of Nucleus

- protons + neutrons
- mass of proton -> 1.673×10^{-27} kg
- mass of neutron -> 1.675×10^{-27} kg
- mass of electron -> 9.110×10^{-31} kg

A Nucleon number (mass #)

Z Proton number (atomic #)

N Neutron number $A = Z + N$

$${}^{A}_{Z}X \quad \underline{\underline{or}} \quad X^{A}_{Z}$$

Isotope -> different # of neutrons for same element.

H^1_1 protium (the nucleus is 1 proton)

H^2_1 deuterium (the nucleus is a deuteron)

H^3_1 tritium (the nucleus is a triton)

D_2O <- heavy water -> has deuterium.

(H_2O)

Nuclide - an atom of a specific isotope characterized by its atomic number and mass number.

atoms of He^4_2 are nuclides

atoms of He^3_2 are nuclides

Interactions within the nucleus

What is the ratio of F_e to F_g for 2 protons in the nucleus?

$$\frac{F_e}{F_g} = \frac{\frac{kq_1q_2}{r^2}}{\frac{Gm_1m_2}{r^2}}$$

$$= \frac{(9.0\times10^{9}\,N\cdot m^2C^{-2})(1.6\times10^{-19}\,C)^2}{(6.67\times10^{-11}\,N\cdot m^2\,kg^{-2})(1.67\times10^{-27}\,kg)^2}$$

$$= 1.24\times10^{36}$$

The repulsive force (electrostatic) is huge in comparison to the gravitational force of attraction.

So what holds the nucleus together?

- gravitational force is ignored in nuclear physics.
- the electrostatic force extends across the nucleus
- The nucleus would be very unstable if there were no other force.

So far we have looked at 2 types of forces:

1. gravitational
2. electromagnetic

So now we have the nuclear force. (more specifically the strong interaction)

The nuclear force holds the nucleons together. and counteracts the electrostatic repulsion between protons.

Properties -> see sheet.