Absorption and Emission of Radiation
Lec6

AP Physics 2

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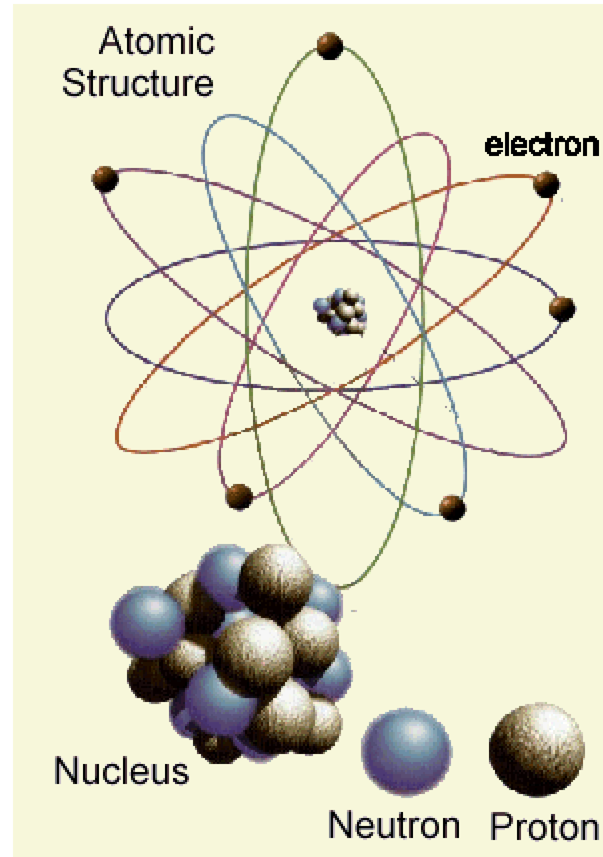
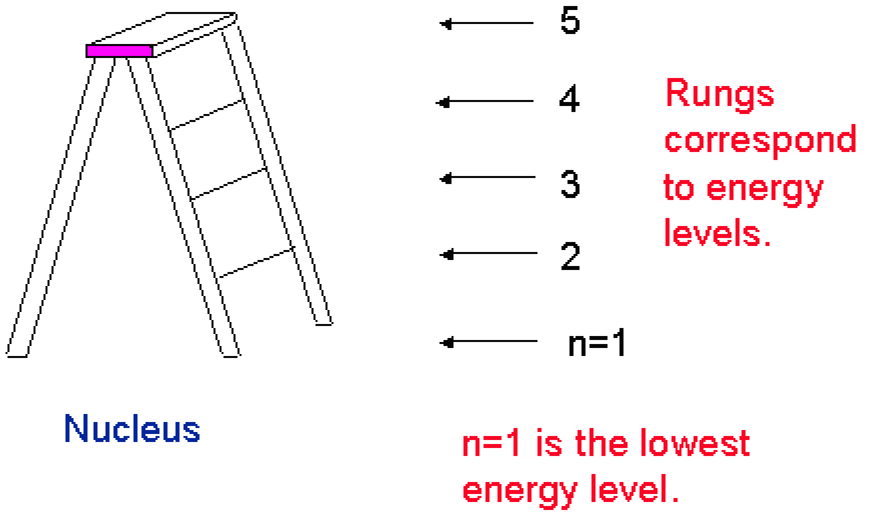
The Atom

As you probably already know an atom is the building block of all matter. It has a nucleus with protons and neutrons and an electron cloud outside of the nucleus where electrons are orbiting and MOVING.

Depending on the ELEMENT, the amount of electrons differs as well as the amounts of orbits surrounding the atom.



When the atom gets excited or NOT



To help visualize the atom think of it like a ladder. The bottom of the ladder is called **GROUND STATE** where all electrons would like to exist. If energy is **ABSORBED** it moves to a new rung on the ladder or **ENERGY LEVEL** called an **EXCITED STATE**. This state is AWAY from the nucleus.

As energy is **RELEASED** the electron can relax by moving to a new energy level or rung down the ladder.

Energy Levels

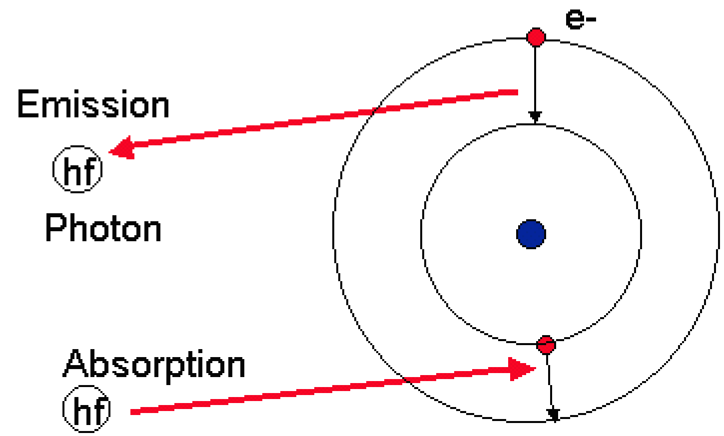
Yet something interesting happens as the electron travels from energy level to energy level.

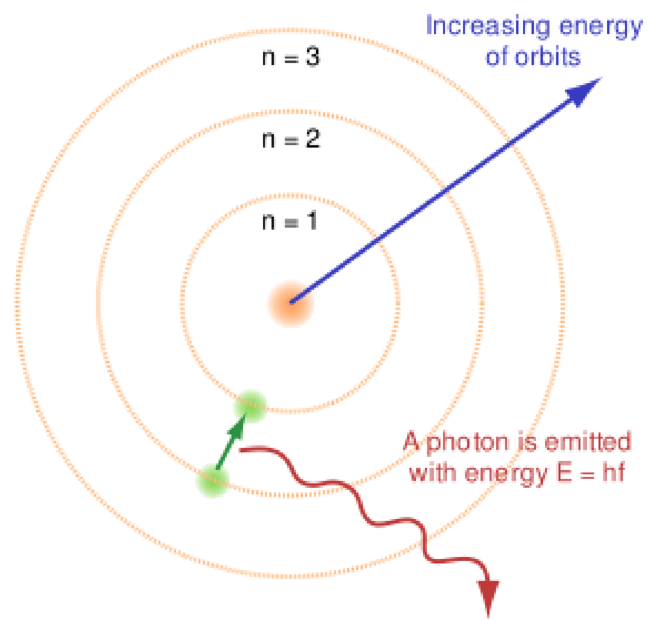
If an electron is **EXCITED**, that means energy is **ABSORBED** and therefore a PHOTON is absorbed.

If an electron is **DE-EXCITED**, that means energy is **RELEASED** and therefore a photon is released.

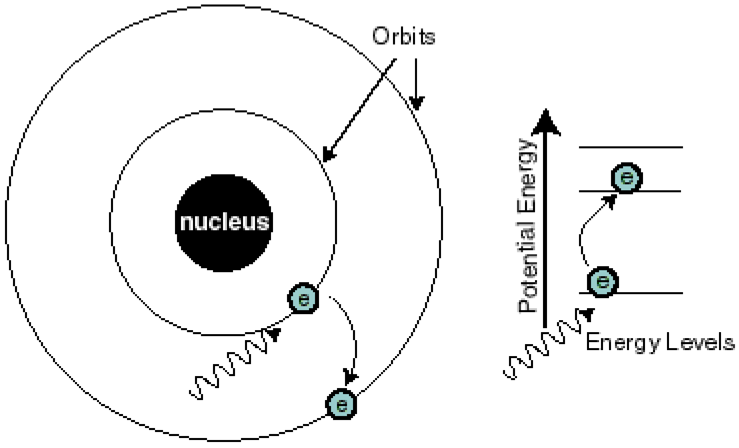
We call these leaps from energy level to energy level QUANTUM LEAPS.

Since a PHOTON is emitted that means that it MUST have a certain wavelength.



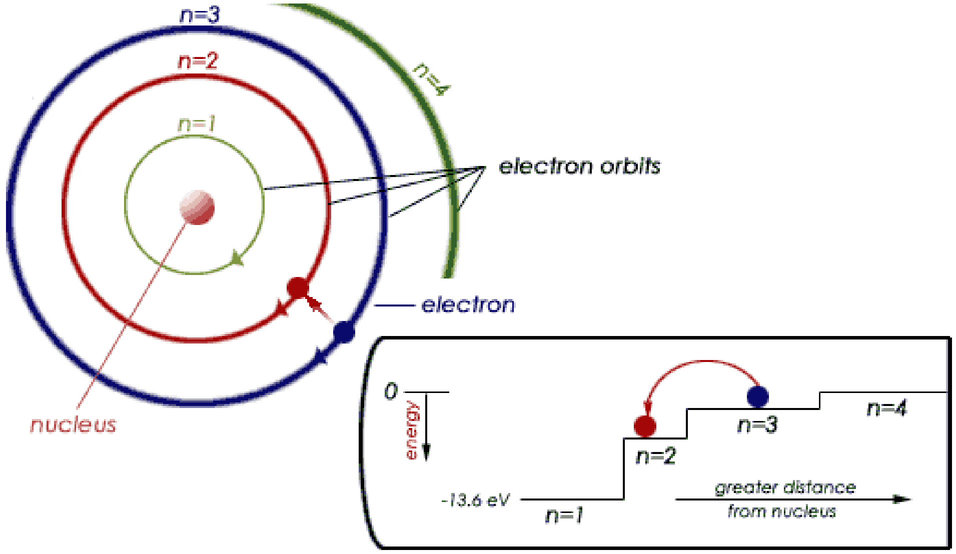


Energy of the Photon

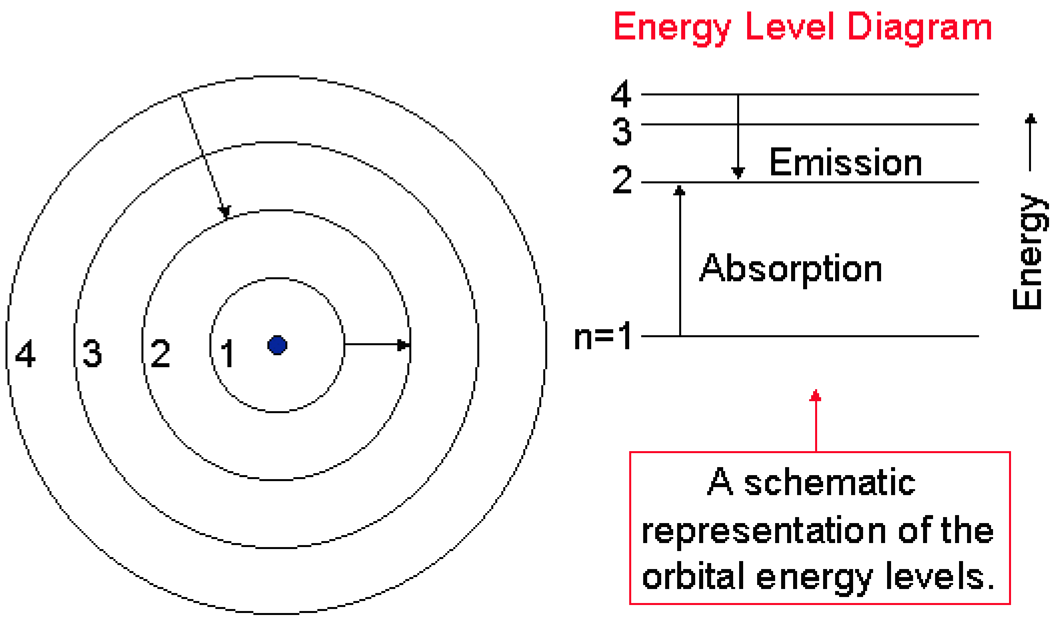


We can calculate the **ENERGY** of the released or absorbed photon provided we know the initial and final state of the electron that jumps energy levels.

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



Energy Level Diagrams



To represent these transitions we can construct an **ENERGY LEVEL DIAGRAM**

Note: It is very important to understanding that these transitions DO NOT have to occur as a single jump! It might make TWO JUMPS to get back to ground state. If that is the case, TWO photons will be emitted, each with a different wavelength and energy.

Example

An electron releases energy as it moves back to its ground state position. As a result, photons are emitted. Calculate the POSSIBLE wavelengths of the emitted photons.

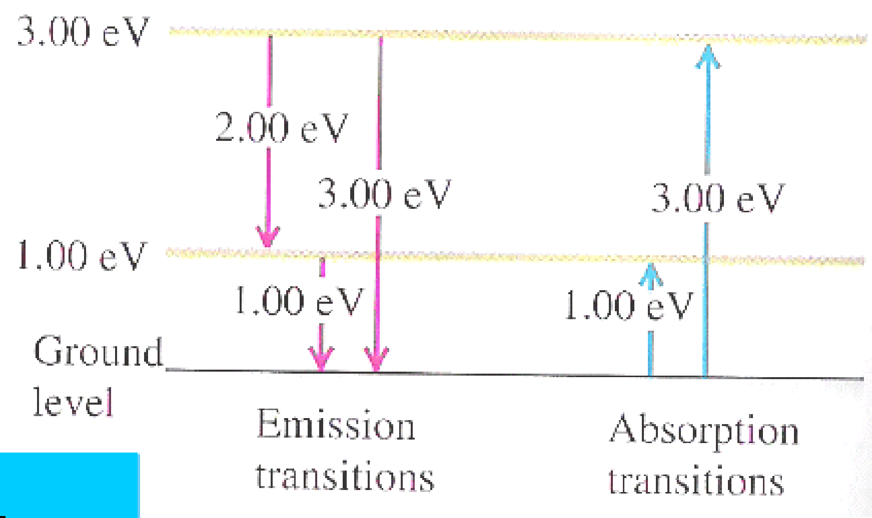
$$\Delta E = hf = \frac{hc}{\lambda}$$

Notice that they give us the energy of each energy level. This will allow us to calculate the CHANGE in ENERGY that goes to the emitted photon.

This particular sample will release three different wavelengths, with TWO being the visible range (RED, VIOLET) and ONE being OUTSIDE the visible range (INFRARED)

Ex1: find the wavelengths of the emitted photons?
constant planck = 6.626×10^{-34} (joules.sec)

Sol:



$$\lambda = \frac{hc}{\Delta E} = \frac{1240 eV \bullet nm}{3eV} = 413nm$$

$$\lambda = \frac{hc}{\Delta E} = \frac{1240 eV \bullet nm}{2eV} = 620nm$$

$$\lambda = \frac{hc}{\Delta E} = \frac{1240 eV \bullet nm}{1eV} = 1240nm$$

- Ex:2

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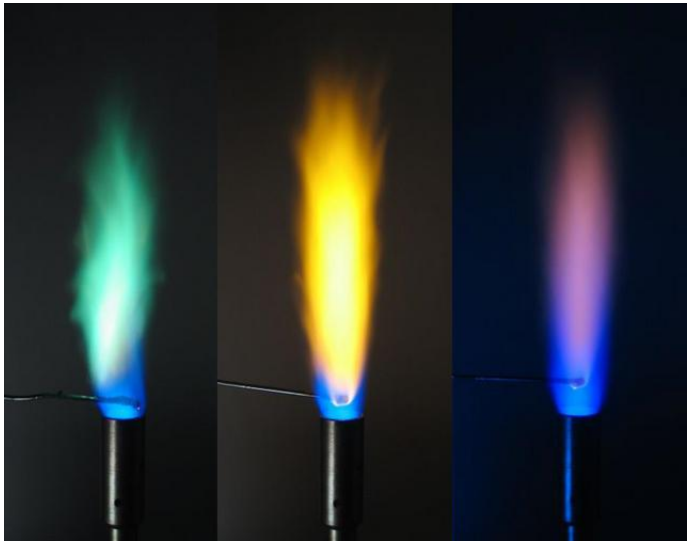
$$E = h\nu \qquad c = \lambda\nu \qquad \nu = \frac{c}{\lambda}$$

$$E = h\frac{c}{\lambda} \qquad 6.63 \times 10^{-34} J.s \times \frac{3 \times 10^{8} m/s}{740 \times 10^{-9} m}$$

[redacted]

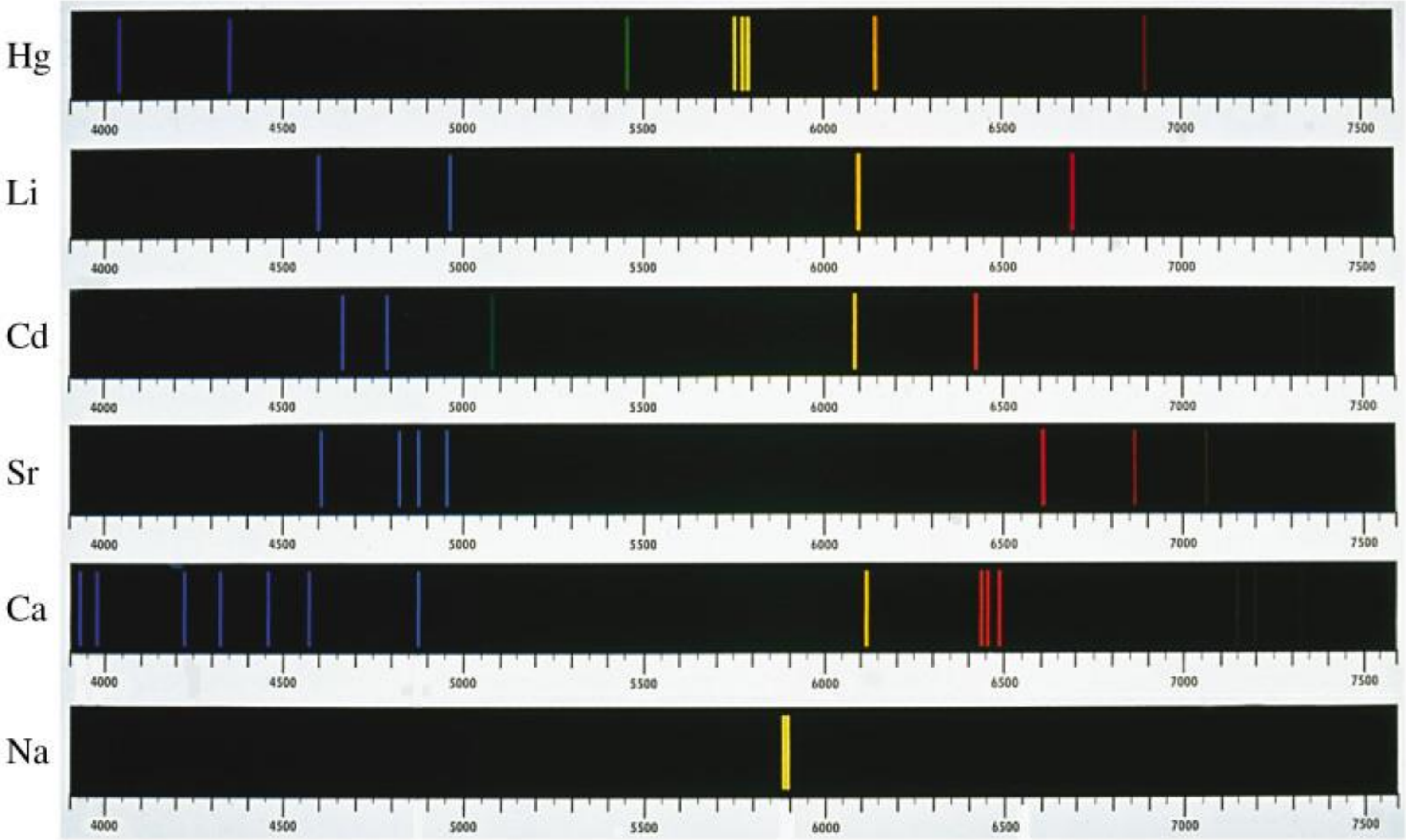
Energy levels Application: Spectroscopy

Spectroscopy is an optical technique by which we can IDENTIFY a material based on its emission spectrum. It is heavily used in Astronomy and Remote Sensing. There are too many subcategories to mention here but the one you are probably the most familiar with are flame tests.



When an electron gets excited inside a SPECIFIC ELEMENT, the electron releases a photon. This photon's wavelength corresponds to the energy level jump and can be used to indentify the element.

Different Elements = Different Emission Lines



Emission Line Spectra

So basically you could look at light from any element of which the electrons emit photons. If you look at the light with a diffraction grating the lines will appear as sharp spectral lines occurring at specific energies and specific wavelengths. This phenomenon allows us to analyze the atmosphere of planets or galaxies simply by looking at the light being emitted from them.