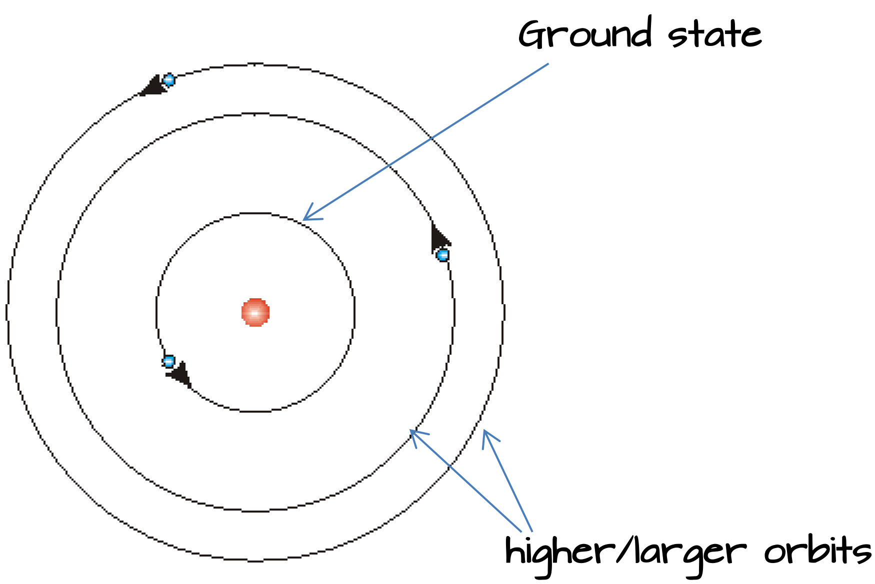
Chemistry Lecture #25: Emission Spectra

We've learned that electrons orbit the nucleus. We've also learned that photons are a form of electromagnetic energy that has a frequency and wavelength. In today's lesson, we'll describe how electrons create photons, and how the wavelength of the photon depends on how the electron moves.

Photons are made by the movement of electrons.

Electrons move between orbits in an atom to make photons.

There are several orbitals surrounding the nucleus of an atom. Electrons occupy these orbitals.

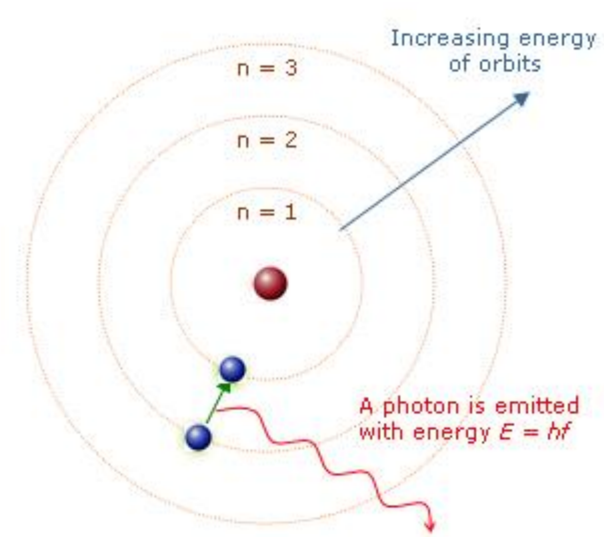


The orbital closest to the nucleus is the *ground state*.

Orbitals further away from the nucleus are higher/larger orbitals.

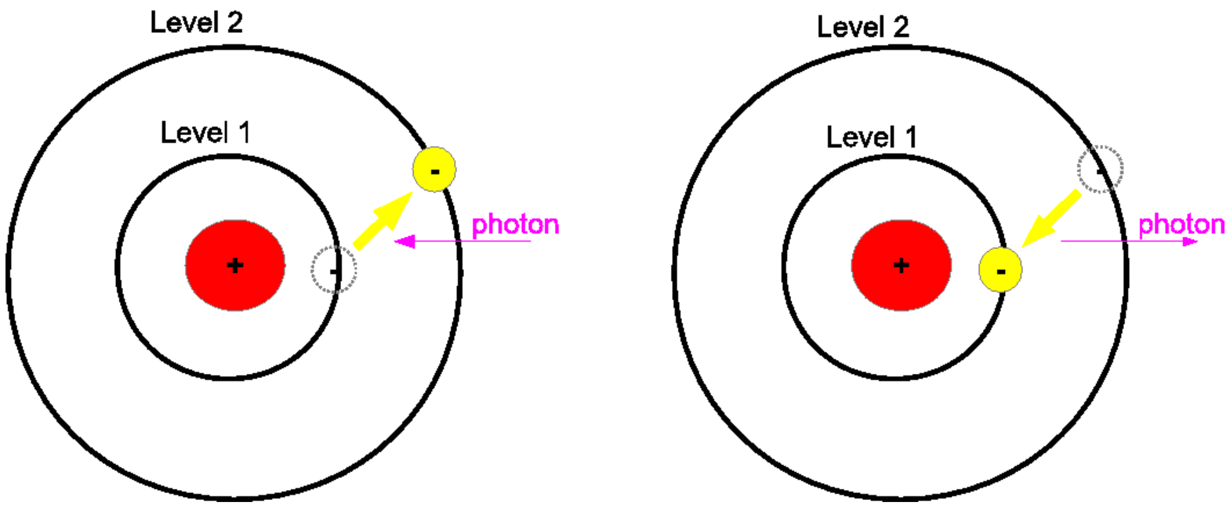
When an electron drops from a higher orbital to a lower one, a photon is produced.

The diagram below shows an electron dropping from the n = 2 energy level to the n = 1 level (ground state). The energy of the photon being produced is calculated from E = hf.



Electrons are attracted to the nucleus. It takes energy to move the electron away from the nucleus. If an electron absorbs a photon, the electron will have the energy to move from a lower to a higher orbital.

The diagram below shows an electron in energy level 1 absorbing a photon, then moving to energy level. 2. It then shows the electron dropping back down from level 2 to level 1 and emitting a photon.



Thus, atoms can absorb or emit photons.

Different atoms emit/absorb photons of different wavelengths.

We can identify atoms by the wavelength of photons absorbed/emitted.

If the wavelengths are between 200 and 700 nm, we see the photons as visible light.

White light is composed of colors. Specific colors have specific wavelengths.

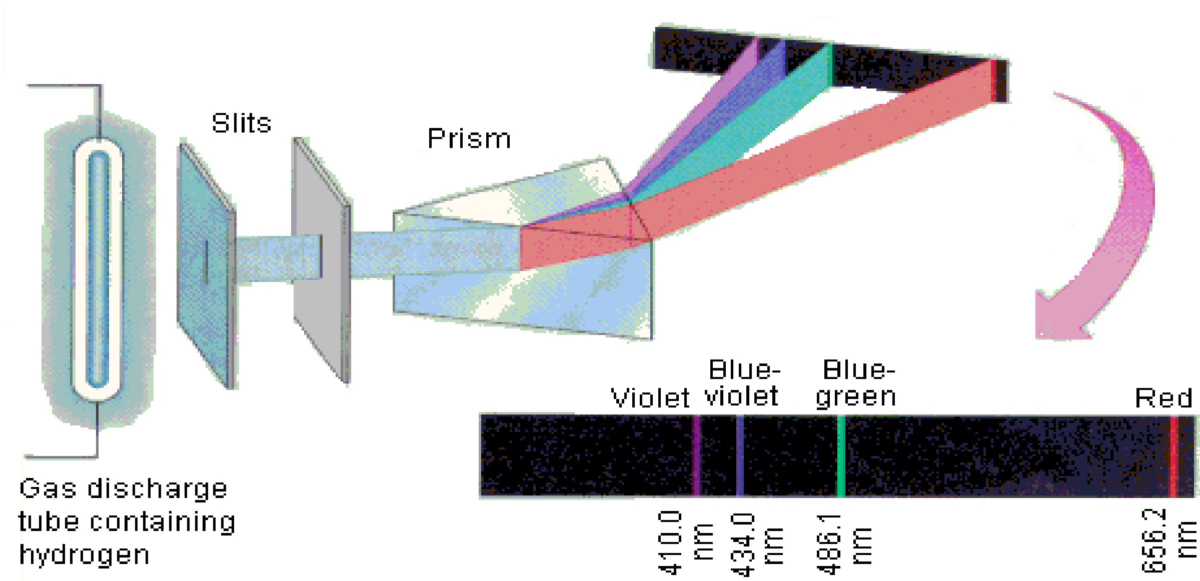
Red	630-760 nm
Orange	590-630 nm
Yellow	560-590 nm
Green	490-560 nm
Blue	450-495 nm
Indigo	464-446 nm
Violet	380-450 nm

Thus, we can identify atoms by the colors absorbed or emitted.

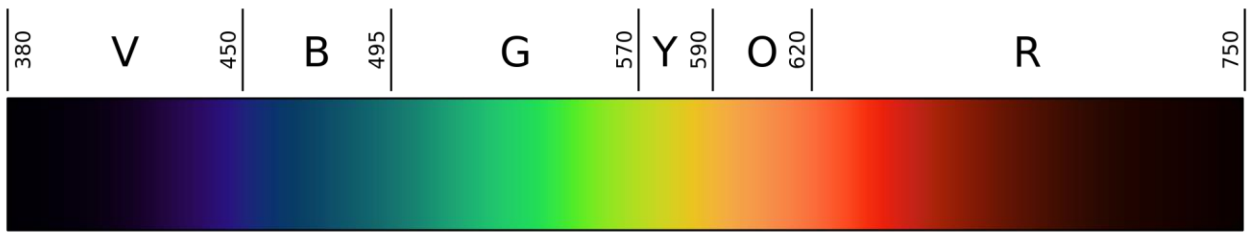
The specific colors emitted by an element is called the *emission spectrum*.

An element will emit colors when heated, or if a stream of electrons (electricity) is passed through it.

Below is a diagram of a tube of hydrogen gas. Electricity is passing through the gas, and the gas is emitting light. The light passes through vertical slits, then goes into a prism. The prism separates the light into the colors red, blue-green, blue-violet and violet. Only hydrogen emits those specific colors at those specific locations on the screen. This is the emission spectrum of hydrogen.

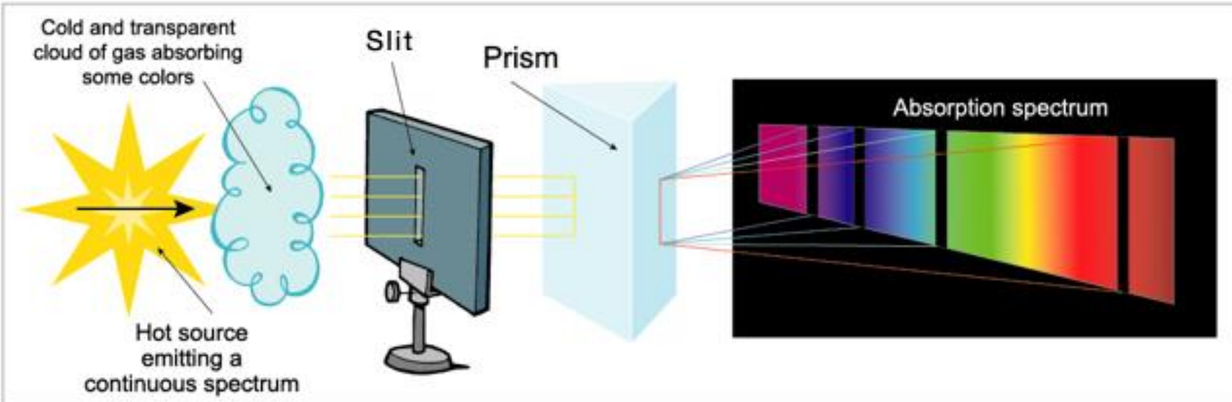


Under some circumstances, substances can produce a continuous spectrum. This is just a fancy way of saying that a substance can produce all the colors of the rainbow and all the different shades of colors. An incandescent lightbulb produces a continuous spectrum, and so does the sun. Here's a picture of a continuous spectrum:

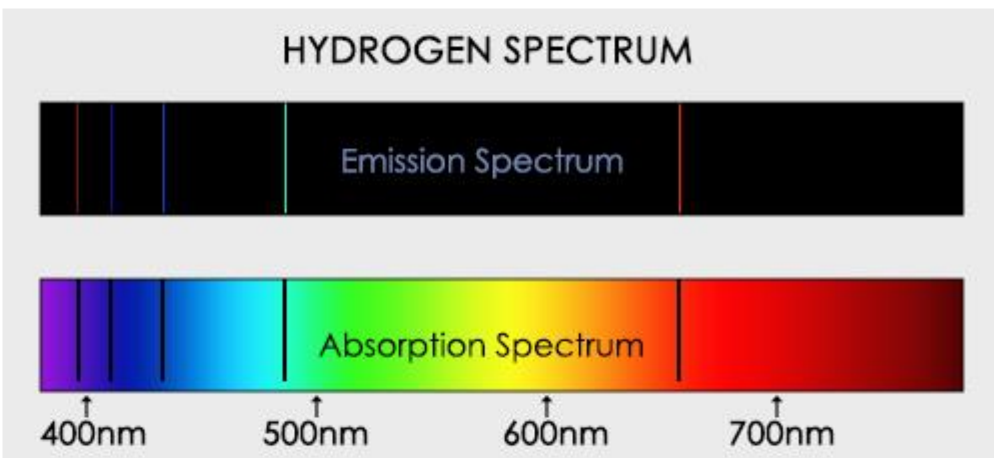


If sunlight were to pass through an element, the element would absorb specific wavelengths of light. If the unabsorbed colors were projected on to a screen, there would be bands of colors missing.

Below is a diagram showing how an absorption spectrum is produced. Light with a continuous spectrum is passed through an element in gaseous form. The gas absorbs some colors, and passes the rest of the colors through a prism. The prism separates the colors and projects them on to a screen. The screen shows something similar to a continuous spectrum, but with black lines at specific locations. The location of these black lines show the colors that were absorbed. The pattern of black lines is the absorption spectrum.



Below is a comparison of the emission and absorption spectrum of hydrogen. Notice that the colors emitted by hydrogen match the colors that are missing in the absorption spectrum.



You can observe absorption and emission when a substance has phosphorescent properties. *Phosphorescence* occurs when a substance absorbs photons, but does not release them all at once. Instead, the photons are gradually released very slowly.

Glow-in-the dark objects exhibit phosphorescence. With these objects, you hold them under a light so they can absorb the photons. Then you can shut off the light, go into a dark room, and see the object glow. It glows because the photons are being slowly released. Below is a photo of some phosphorescent toys.

You can also observe absorption and emission when a substance undergoes *fluorescence*. Fluorescence occurs when a substance absorbs photons with a short wavelength, then emits photons with a longer wavelength..

A black light bulb emits ultra violet light, which is invisible and has a shorter wavelength than visible light. If an object is marked with fluorescent ink, the ink can be made visible if it is exposed to uv light. The ink absorbs the invisible, shorter wavelength uv light, then emits the longer wavelength visible light.

Objects that are marked with fluorescent inks include paper money, credit cards, and a driver's license.

Below is a photo of U.S. currency under uv light. Notice the thin band of color that cuts across the bills from top to bottom. This band of color is the fluorescent ink that becomes visible under uv light.