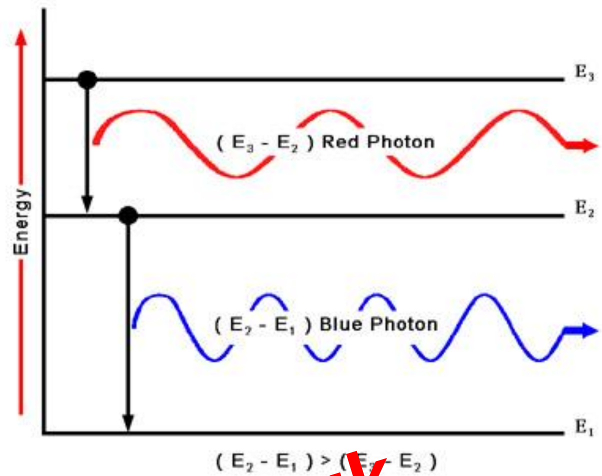
The production of colored light in neon signs is an example of this process.

When investigators passed electric current through a vacuum tube containing hydrogen gas at low pressure, they observed the emission of a pinkish glow. *When a narrow beam of the emitted light was shined through a prism, it was separated into four specific colors of the visible spectrum*. The four bands of light were part of what is known as hydrogen's **line-emission spectrum**. Additional series of lines were discovered in the ultraviolet and infrared regions of hydrogen's line-emission spectrum. These are known as the Lyman, Balmer, and Paschen series.

Classical theory predicted that hydrogen atoms would be excited by whatever amount of energy was added to them. *The emission of a continuous range of frequencies of electromagnetic radiation is a* **continuous spectrum**.

Whenever an excited hydrogen atom falls to its ground state or to a lower-energy excited state, it emits a photon of radiation. The energy of this photon ($E_{photon}=hv$) is equal to the difference in energy between the atom's initial state and its final state. The fact that hydrogen atoms emit only specific frequencies of light indicated that the energy differences between the atom's energy states were fixed, which suggested that the electron of a hydrogen atom exists only in very specific energy states.

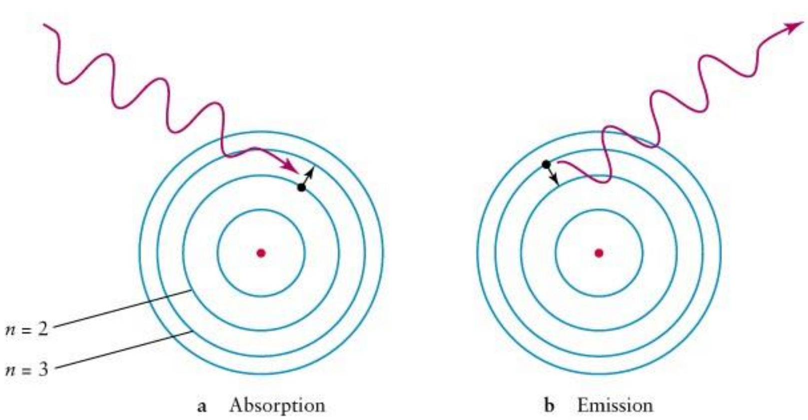


When an excited atom with energy E_2 falls back to energy E_1, it releases a photon that has energy $E_2 – E_1 = E_{photon}=hv$.

Bohr Model of the Hydrogen Atom

The hydrogen-atom spectrum was solved in 1013 by Niels Bohr. He proposed a hydrogen-atom model that linked the atom's electron can circle the nucleus only in allowed paths, or orbits. When the electron is in one of these orbits, the atom has a definite, fixed energy. The electron—and therefore the hydrogen atom—is in its lowest energy state when it is in the orbit closest to the nucleus. This orbit is separated from the nucleus by a large empty space where the electron cannot exist. The energy of the electron is higher when the electron is in orbits that are successively farther from the nucleus.

While in a given orbit, the electron is neither gaining nor losing energy. It can, however, move to a higher-energy orbit by gaining an amount of energy equal to the difference in energy between the higher-energy orbit and the initial lower-energy orbit. When a hydrogen atom is in an excited state, its electron is in one of the higher-energy orbits. When the electron falls to a lower energy level, a photon is emitted and the process is called *emission*. The photon's energy is equal to the energy difference between the initial higher energy level and the final lower energy level. Energy must be added to an atom in order to move an electron from a lower energy level to a higher energy level, called *absorption*. The energy of each absorbed or emitted photon corresponds to a particular frequency of emitted radiation, $E_{photon} =hv$.



(a) Absorption and (b) emission of a photon by a hydrogen atom according to Bohr's model. The frequencies of light that can be absorbed and emitted are restricted because the electron can only be in orbits corresponding to the energies E_1, E_2, E_3 ,E_4 and so forth.