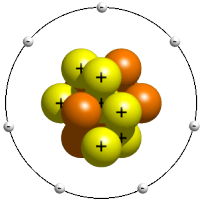
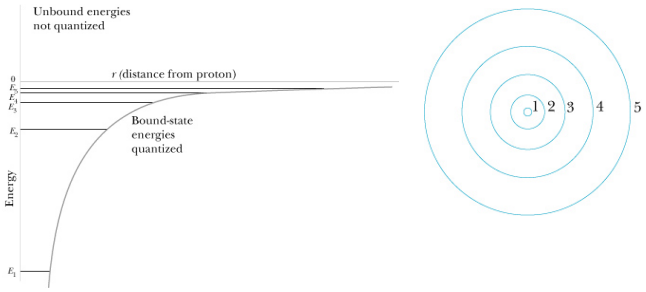
Chapter 7 – Energy Quantization

An introduction to the world of quantum mechanics

Energy of a hydrogen atom (classical)



Quantized Energy (energy states)



N=1 is the ground state; N=2 is the first excited state, etc.

Poll

A hydrogen atom is in its first excited state. What is the minimum energy that must be input into the system in order to break apart the electron and proton, meaning that the electron will just barely escape the proton.

1. 3.4 eV
2. -3.4 eV
3. 13.6 eV
4. -13.6 eV
5. zero

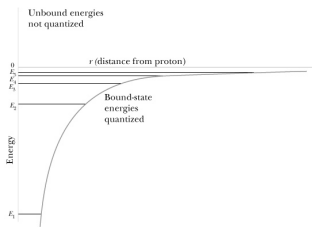
Poll

A hydrogen atom is in its second excited state. If it gains 0.66 eV of energy

1. It will no longer be bound.
2. It will still be bound, but at a higher energy.
3. It will still be bound, but at a lower energy.

Change in Energy

Because only certain energy orbits are allowed, the hydrogen atom can only gain or lose energy in an amount that corresponds to a change in the allowed orbits.



Poll

Hydrogen is in its ground state. Which of the following is possible?

1. The atom can gain 1 eV of energy.
2. The atom can lose 1 eV of energy.
3. The atom can gain 3.4 eV of energy.
4. The atom can lose 3.4 eV of energy.
5. The atom can gain 10.2 eV of energy.
6. None of the above.

Poll

If a hydrogen atom gains 1.89 eV, what was its initial state and what was its final state?

1. N_i=1 and N_f=2
2. N_i=2 and N_f=3
3. N_i=1 and N_f=3
4. N_i=2 and N_f=4
5. None of the above.
6. There is more than one possible transition.
7. There is not enough information to answer the question.

Poll

A hydrogen atom's energy changes from N=4 to N=2. The atom

1. Lost energy
2. Gained energy
3. Has a constant energy, so its energy did not change.

Photon (particle model of light)

Light is made up of massless particles called photons. A photon only has kinetic energy, and its energy is

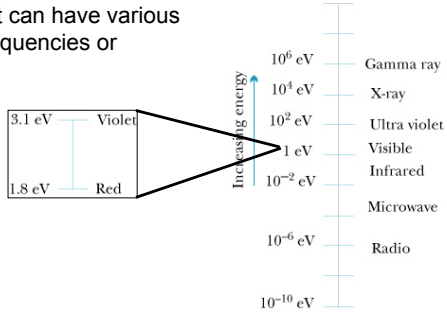
$$E = hf$$

h = 6.63 × 10^{-34} J s

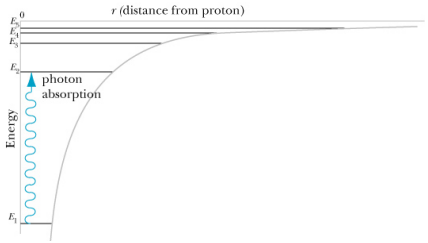
h = 4.14 × 10^{-15} eV s

Electromagnetic Spectrum

Photons of light can have various energies (or frequencies or wavelengths).

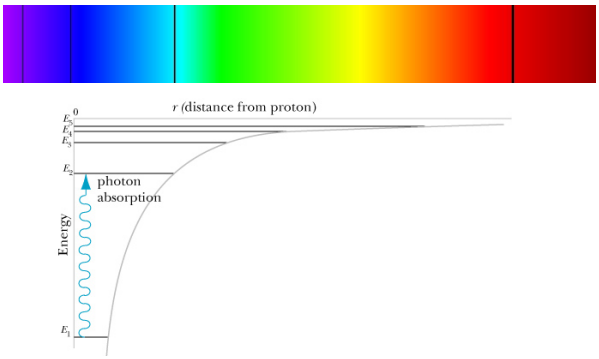


Photon Absorption

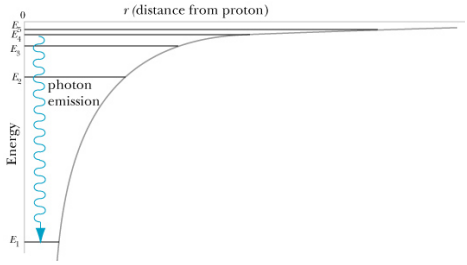


Continuous Spectrum

Absorption Spectrum



Photon Emission



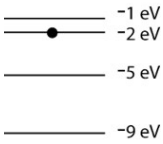
Poll

In what region of the spectrum is a photon absorbed by hydrogen in its ground state?

1. Gamma
2. X-ray
3. UV
4. Visible
5. IR
6. Radio

Poll

Suppose that these are the quantized energy levels (K+U) for an atom. If the atom is excited to the second excited state (marked by a dot), what are the possible energies of photons it might emit?



1. 2, 5, and 9 eV
2. 3, 4, and 7 eV
3. 3 or 7 eV
4. 5 or 9 eV
5. 2 eV

Poll

Imagine an atom which only has two electronic energy levels. The ground state energy is -3.0 eV and the excited state has an energy of -1.2eV. I irradiate a sample containing many atoms with visible light which contains photons of all energies from 1.8 eV up to 3.1 eV.

What will be the energy of the missing (i.e. absorbed) photons?

1. No photons will be missing.
2. 1.2 eV
3. 3.0 and 1.2 eV
4. 3.0 eV
5. 1.8 eV

Poll

Light consisting of photons with a range of energies from 1 to 7.5 eV passes through this gas. The gas is kept very cold so that all atoms are in the ground state.
What photon energies will be absorbed from the light beam ("dark lines")?

1) 2 eV, 5 eV, 9 eV
2) 3 eV, 4 eV
3) 0.5 eV, 3 eV, 4 eV
4) 4 eV, 7 eV
5) 3 eV, 4 eV, 7 eV