11. Spectroscopy: Electron Transitions and Light Emission

Whenever light and an atom interact, energy is exchanged. Since energy is conserved, if the atom loses energy, it is released as light (this process is called emission); if the atom gains energy, this gain is from taking in light (absorption); such that:

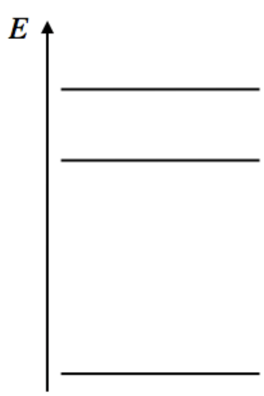
$$\Delta E_{atom} + \Delta E_{light} = 0. \tag{1}$$

Observation shows that such interaction happens only at very specific frequencies of light. Such frequencies are “quantized” and are called “resonant” frequencies, because the oscillations of the electric field of the light match (are in resonance with) the frequencies of motion of the electron cloud in the atom (analogous to IR frequencies matching the frequencies of movement atoms within a molecule and its bonds).

In this activity we will use energy diagrams to represent this resonant interaction. The image below shows the emission of two colors of light: red and green. The amount of energy exchanged in the light-matter interaction depends on the color of the emitted light. Using this image and the information stated above, answer the following questions.

1) Explain which emission line represents the greatest change in energy of the atom, $|\Delta E_{atom}|$? *(Hint: Think about the relationship between energy and wavelength.)*

2) Energy change is always represented on an energy diagram by an arrow between two energy states. On the energy diagram below, draw two arrows that correspond to the relative energies of the red and green light that is **absorbed**. Assume that the absorption occurs from the lowest energy state. Mark which arrow corresponds to the red light and which corresponds to green light.



3) Does the red line correspond to an increase in energy of the atom ($\Delta E_{atom} > 0$), or a decrease in the energy of the atom ($\Delta E_{atom} < 0$)? Explain. What about the green line?
(Hint: Think about the ***direction*** *of the arrow as well as the factors that affect the magnitude of the arrow.)*

4) Based on your diagram in (2), draw another energy diagram that shows the **emission** of red and green light such that both energy changes end at the same final energy state.