Goodie bag #2: Electronic Transitions

Handed out on 9.14.18 | Quiz #2 on 9.20.18

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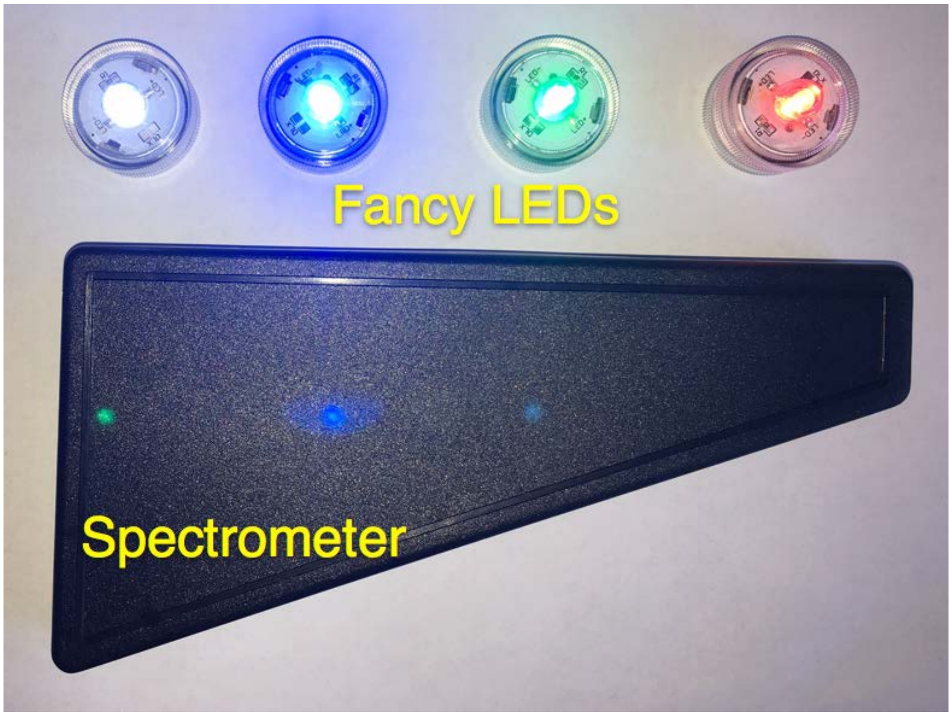
Do yourself a solid.

This bag contains:

- A really cool spectrometer
- A set of fancy LED lights



What to bring to the quiz: your spectrometer

Introduction

When electrons are excited and then relax to their ground state, they can emit light at wavelengths characteristic of the energy transitions between the different electronic energy levels. In this Goodie Bag, you use a spectrometer to see which wavelengths are there – or not there – in a given light source. If the light is emitted from an atom, these wavelengths can be converted into energies, and the energies can then be converted into specific electronic transitions using the Bohr Model.

Instructions & Questions

In addition to the spectrometer, you have been given 4 different fancy LED lights: red, green, blue, and white.

Question 1: Getting used to the spectrometer.

Take a look through the spectrometer at natural light (coming in from a window, for example). Is the spectrum continuous, or do you see any gaps? Please explain why light observed from the sun is or is not continuous.

Question 2: What's missing?

Now take a look through the spectrometer at other light sources, in your dorm for example. Is there a dependence on the type of light bulb? Do you sometimes see gaps in the spectrum?

Question 3: Getting quantitative.

These colors, or the absence of them, that you see in the spectrum through your spectrometer correspond to different wavelengths of light. As we learned in lecture, a photon of a given wavelength can also be viewed as an amount of energy. If you take the spectrometer to your nearest hydrogen gas lamp, you might see something like this:

Those are spectral lines that have certain energies. Which one has a lower energy and what is it in electron Volts?

Question 4: Applying the Bohr model.

The red line comes from an electron in the hydrogen atom that was excited to some state and then relaxed down to the n=2 state by giving off a red photon. What is the value of n for the excited state?

Question 5: Red, green, blue LEDs.

Now use your spectrometer to look at the three different LED colors: red, green, and blue, that you were given in the Goodie Bag. Notice that in each case there is not a sharp line as we saw for hydrogen but rather a distribution around each color.

a) Which color has the broadest distribution and which on the narrowest distribution?

b) For the case of the red LED, what is the energy of the highest energy photon you see in the distribution?

c) If the light for the red LED were coming from a n=11 to n=10 transition for a certain atom, use the Bohr model to determine which atom. Assume a wavelength of 650 nm.

Question 6: Fixing the white LED.

Use your spectrometer to look at the white LED that you were given in the Goodie Bag. Notice that unlike the nice continuous distribution of natural light, for the white LED there is a gap in the spectrum (this might appear as a sharp gap or it might be a dimmer signal).

a) What is the wavelength of the missing light?

b) In order to make LEDs appear more like natural sunlight, you develop a chemical coating for the bulb that fills in the missing wavelength. It works by absorbing 4.47 eV UV light and converting it into visible light. Suppose the coating were made of phosphorous atoms that are isolated from one another so the Bohr model applies. If the initial state of an electron in the P atom is n=20, to what energy level does it go upon UV absorption?

c) Now that the electron has been excited to the level you found in part (b), to what level does it decay in energy in order to emit a photon of the right wavelength to fill in the missing light from the white LED?