Light Inquiry Lab; SC4 a,b.


Niels Bohr discovered that the energy levels for electrons were quantized, meaning that only certain, specific energy levels were possible. How does an electron move between energy levels? By gaining the right amount of energy, an electron can move, or undergo a transition, from one energy level to the next. We can explain the emission of the light by atoms to give the line spectrum like this: 1) An electron in a high energy level (excited state) undergoes a transition to a low energy level (ground state). 2) In this process, the electron loses energy, which is emitted as a photon (a particle which behaves like a wave. 3) The energy difference between the high energy level and the low energy level is related to the frequency (color) of the emitted light. The purpose of this lab is to explore electron movement, quantization of electrons and light through the process of inquiry. Please read each activity before you proceed.

Activity 1: Obtain two ~6 cm pieces of clear scotch tape. Fold old back about a 0.5 cm section to make a little tab. Stick the two pieces on a student desk side by side. Vigorously rub and scrape the two pieces of tape. Slowly remove both pieces of tape. Now slowly move the adhesive sides of the tape towards each other. Experiment with various movements of the tape. Repeat if necessary.
Q1. Thoroughly describe your observations. Write an explanation for this phenomenon and be sure to include the movement of electrons in your answer. How could such observations have led to the discovery of sub-atomic particles?

Activity 2: Obtain and inflate a balloon. Next, turn on a fine stream of water at your lab station. Vigorously rub the balloon on your hair. Now hold the balloon near the stream of water. Experiment with various movements of the balloon.
Q2. Draw a schematic diagram that illustrates this phenomenon. Be sure to consider water's polar structure and the orientation of the electrons. How might these observations have contributed to the early research done by scientists like Thomson and Bohr?

Find another group with a balloon and experiment with various configurations of the two balloons. Try holding the balloon to the wall.
Q3. Describe what happened with another group's balloon. What about the wall?

Activity 3: Obtain four ~10 cm pieces of duct tape. Stick two pieces together, but leave a little tab to be able to pull them apart later. Repeat this with your other two pieces so that you have two strips of tape adhered to one another. Lay the pieces on the table and rub them to insure each is stuck together well. You will complete the remainder of this activity in the auditorium per verbal instructions.
Q4. After completing this activity, describe your observations. Sub-atomically speaking, what occurred?

Demonstration 1: "The Wheel of Light" This demo will be conducted in the auditorium.
Q5. Describe the demonstration and explain your observations in terms of the electromagnetic spectrum. What are the approximate wavelengths for the three lights used in this demo?

Activity 4: Obtain two wintergreen Lifesavers per group, so that each student has one. The following activity will be conducted in the auditorium per teacher instructions. Place wrappers in the trash.
Q6. Describe your observations. Draw a schematic that shows the movement of electrons and photons. Use the terms light emittance, light absorption and ground state in your answer. These terms were discussed in a recent podcast.

Activity 5: Turn on the television in the classroom. Obtain a magnet and experiment by moving the magnet around the television screen. Repeat as necessary. Do not hold the magnet in one area too long.
Q7. Describe you observations in detail. How can you explain your observations? Justify your response.

Activity 6: Obtain a spectroscope with a diffraction grating. To view the spectroscope properly, you should see a white vertical slit in the upper right corner and the numbers 7, 6, 5, 4 on the lower left along with the visible light spectrum. To view a light correctly, you need to aim the vertical slit at the light. Please practice before you move on. Now that your group has practiced it is time to view several different light sources. For the following questions, you can read the information sheet that accompanies this station titled, "EnVision *LABS*".
Q8. For each light source, describe the spectrum of colors. Are there any "other" wavelengths of light present that are not visible through the spectroscope? Defend your answer.
Q9. These various light sources actually contain different elements. Why do the various elements present in these light sources emit different spectra? How are they like chemical fingerprints?

Q10. When you look through the scope, the numbers represent angstroms multiplied by 1000. So the number 7 is actually 7,000 angstroms. Look at the tungsten (W) incandescent bulb and record the value for indigo in angstroms. If 1 angstrom is 1 x 10^{-10} meters, than what is the length of indigo in kilometers? Show your work.

Activity 7: Obtain a piece of copper wire. Light a Bunsen burner and hold the wire over the flame. Be sure wear safety goggles and to wear thermal gloves or hold the wire with tongs. Carefully observe the wire.
Q11. Describe your observations in detail. What sub-atomic changes led to these observations? What happened to the subatomic particles as the wire cooled? Why are metals described as ductile?

Activity 8: Obtain a slinky and a tape measure. Go out into the hall where you will produce transverse waves on the floor. Trial 1: Spread out a distance of _________. Please do not overstretch the slinky. Shake your hand back and forth (flat on the ground) at a constant rate and observe. Stop and answer the next question.
Q12. Describe the amplitude, frequency and wavelength of your transverse (light) waves.

Trial 2: Now, reduce your distance to _________. Repeat the motion to create more light (transverse) waves and observe. Next, try to create a standing or stationary wave, even if it is for just a few seconds.
Q13. Describe the amplitude, frequency and wavelength of your transverse light waves for trial 2. How did these measurements change from the first trial? Compare and contrast the "energy" of the two trials. How were you able to create a standing wave?

Activity 9: Fluorescence and phosphorescence are both examples of photoluminescence. In both cases, light is absorbed and then re-emitted at a less-energetic wavelength. Fluorescent and phosphorescent objects usually glow under exposure to ultraviolet light. Fluorescence involves absorbing and releasing lower energy light almost immediately, while the light release of phosphorescence is delayed, so these materials appear to glow in the dark. Procure a black light (ultra-violet light) and be careful not to drop the light as you are using it. Walk around the classroom and look for any excited electrons that might exhibit the aforementioned properties. Explore.
Q14. You should have found several areas that exhibited photoluminescence. Which type of photoluminescence did you observe and why? How could this property of light be utilized by a forensic scientist or in the medical field?

Post Lab Questions:

1. Describe what it means for electrons to be "quantized"? Why are electrons quantized?

2. Examine the electromagnetic spectrum posters in the classroom. There are four types of electromagnetic radiation and each can be characterized by wavelength, frequency, photon energy and speed of travel. Rank the four types of electromagnetic radiation in order of increasing wavelength, frequency, photon energy and speed.

3. Transcribe and fill in the following table and be sure to use the electromagnetic spectrum posters in the classroom:

Energy (Joules)	Wavelength-λ (meters)	Frequency –ν (s^{-1})	Color of Light/type of electromagnetic radiation
6.3 x 10^{-19} J			
	2.4 x 10^{-7} m		
		100 s^{-1}	
1.5 x 10^{-14} J			
	5.6 x 10^{-10} km		
		2.2 x 10^{13} s^{-1}	
	525 nm		

$$\text{Energy of photon } E = h\nu = h\frac{c}{\lambda}$$