Atomic Theory: Spectroscopy and Flame Tests

Procedure:

PART I. SPECTROPHOTOMETRIC ANALYSIS OF LIGHT

Often your instructor will turn on the spectrometer before you start the experiment. If the spectrometer is off, then make sure there is not a piece of paper in the sample holder. Turn on the “Spec-20 Genesys” spectrophotometer, using the switch on the back side of the instrument. It will take about 15 minutes for the spectrometer to warm up before use.

On the top right of the instrument is a sample holder that holds the sample cells, called “cuvettes”. Never insert chemicals directly into the Spec-20, or you will contaminate and damage it. To the left of the sample holder is a panel of buttons that control the wavelength (in nanometers) and output (percent transmittance or absorbance) settings. The up/down arrows that you should use have the units “nm” on them. These up/down arrows turn the prism-like device in the Spec-20, so light of only one wavelength strikes the sample in the cuvette. When the spectrometer is started,

Place a piece of filter paper in the sample holder to reflect the light beam within the spectrophotometer. Before adjusting the wavelength, check to make sure you see the color of the initial 546 nm light from the spectrometer.

Use the up/down arrows to scroll through wavelength values from 400 nm to 750 nm in 25 nm increments to find the colors corresponding to the different wavelengths of the visible spectrum. Use colored pencils to color in the spectrum in the box on your report sheet to show the correlation between color and wavelength. Note: There will be many more shades of color than the seven used in the often-used pneumonic device ROYGBIV (which means: Red, Orange, Yellow, Green, Blue, Indigo, and Violet). Therefore, you may have to use some creative color blending to represent the entire spectrum.

PART II: Gas Discharge Demonstration

Your instructor will show samples of gas collected in thin glass tubes known as gas discharge tubes. The ends of the tubes have electrodes that allow a current to pass through the gas and light up. When inserted into a voltage source, the samples will glow a characteristic color. When the light is diffracted (e.g., with a prism or the diffraction glasses we will be using in class), you can see the separate spectral lines that make up each sample. In the 2 boxes at the top of your Lab Report, draw color representations of the diffracted light from the two gas samples your instructor shows. Label each prominent line in each spectrum with the wavelength of that emission line.
PART III: FLAME TESTS

**Lab Notebook**

In this lab, you will record ALL data directly into your lab notebook. Read through the directions for the flame tests at least once and then think about how you would create a table to organize your experimental data. Here are a couple of hints:

- You will be testing 6 known solutions: Li(NO$_3$)$_3$, Cu(NO$_3$)$_2$, Sr(NO$_3$)$_2$, Ba(NO$_3$)$_2$, KNO$_3$, and NaNO$_3$.
- You will label test tubes for your known solutions (from 1-6). Each known solution should correspond to a unique number.
- For each solution, you will need to describe the emission color of the flame during the test.
- You will also be testing an unknown solution. You will need to describe the emission color of the flame and determine the identity of the solution.

You will conduct flame tests to observe the flame emission colors for the known solutions. Since nitrates (NO$_3^-$) do not emit color, you will observe the color of the emission of the cations.

**Safety precaution:** Do not touch the chemicals on the splints with your fingers! Wash your hands immediately if you accidentally touch the chemicals on any of the splints.

1. Label your 6 test tubes with a pencil – one for each solution listed above. From the reagent station, put about 10 – 12 drops of each solution into the appropriate test tube. Place one splint into each test tube. These should soak for about 5 – 10 minutes in order to absorb enough solution.
2. At this time, each group should obtain one unknown from your instructor. Get a splint, and place it in the test tube of the unknown to allow sufficient time to soak. Be sure to record your unknown number in your lab notebook.
3. Prepare your 150 mL beaker with about 20 – 40 mL of water to dispose of the used splints.
4. Light your Bunsen burner with a striker. Your instructor will check to make sure that your flame is adjusted properly for the activity. You should see two blue cones of flame.
5. Grasp the LiNO$_3$ wood splint by the tip and place the damp end of the splint in the middle of the flame (in the tip of the inner cone) for a short time (about 2 – 3 seconds). You should see the color of the metal ion burning in the first few seconds.
6. Avoid burning the wood splint itself. A wet splint cannot burn. If you start to notice the splint burning, it was in the flame past the point of dryness. If it does start to burn, you should immediately dip the splint back into the correct test tube to put out the flame, re-wet the splint and test the flame color again. You can repeat this several times if you have difficulty seeing the color.
7. When you are done testing a splint and its solution, dispose of the burned splint in the 150 mL beaker.
8. Observe and carefully describe the color of the flame on the data table. For example, describe the color as pinkish red or violet red instead of just red.
9. Continue with the other solutions, recording the flame color for each solution. Be as descriptive and accurate as possible.
10. Observe and record the color given off by your unknown in the same manner. Identify the metal in your unknown solution.
11. When you have finished with all splints and solutions, dispose of all materials in the proper solid or liquid waste container in the hood.
PART IV. ABSORPTION AND EMISSION SPECTRA: A WEB TUTORIAL

The fourth activity of this lab involves an interactive tutorial to help explain the process electrons go through when absorption and emission spectra are obtained from pure substances. Go to the Website below (a link is provided on the webpage for this week’s experiment):


Click on the Chemtour Light Emission and Absorption. Note the section numbers (e.g. “Section 2 of 4”) indicated at the bottom of each page during the tutorial. Be sure to click on the links for Real-World Connections, Science Connections, and Concept Questions during the tutorial. You may want to explore other Chemtours to learn more.

Answer the questions on Part IV of your report sheet. You may refer back to each specific section in the tutorial as often as needed.
**Atomic Theory: Spectroscopy and Flame Tests**

Name: _______________________
Partner(s): ___________________
Section Number: _______________

***Turn in these pages with the lab report! (pp. 4-6)***

I: Spectrophotometric Analysis of Visible Light

Shade in all colors between the wavelengths (in nm) listed below:

<table>
<thead>
<tr>
<th>400</th>
<th>425</th>
<th>450</th>
<th>475</th>
<th>500</th>
<th>525</th>
<th>550</th>
<th>575</th>
<th>600</th>
<th>625</th>
<th>650</th>
<th>675</th>
<th>700</th>
<th>725</th>
<th>750</th>
</tr>
</thead>
</table>

II: Gas Charge Demonstration

Pre-lab: Gas Discharge Demo
Before putting the diffraction glasses on, identify the element being shown in the discharge tube and its color (be descriptive with the color). Now put the glasses on, and draw exactly what you see as best you can, emphasizing specific lines of color. You should include one full spectrum of diffracted light. This data should be recorded directly in your notebook, then copied here as neatly as possible for your report.

Sample 1 – Gas: ________________  Color of lamp: __________________

Spectral Lines

Sample 2 – Gas: ________________  Color of lamp: __________________

Spectral Lines
Part III: Flame Tests

(The data and results for the flame tests should be recorded in the lab notebook only)

1. Describe the difference between the lithium emission and the strontium emission in the flame tests.

Part IV: Online interactive tutorial:

Answer these questions in your own words. Do not restate what the tutorial says word for word, as this would be plagiarism.

1. Describe the difference between the ground state and the excited state of an atom.

2. Describe what happens to an electron when it absorbs energy. Describe the location of the electrons in terms of energy levels and distance from the nucleus.

3. Describe what happens when an electron in an excited atom returns to its ground state.

4. The emission spectrum of hydrogen gives four distinct wavelengths representing four colors of light. The tutorial lists the colors as: violet (410nm), blue (434nm), green (486nm), and red (656nm).
   - Which color of light in the visible emissions spectrum for hydrogen has the highest energy photons? Explain.
Questions and Calculations: (You must show all of your work on calculations to receive full credit.)

1. Determine if energy is absorbed or emitted for each electron transition in a hydrogen atom:
   a. From \( n = 4 \) to \( n = 2 \)  
      emitted absorbed
   b. From \( n = 2 \) to \( n = 6 \)  
      emitted absorbed

2. You are the student representative for Glendale Christmas fireworks display. Explain which chemicals should be used in the fireworks to have the fireworks match the traditional Christmas decorations. (Hint: Consider your flame test results.)

3. KSLX FM radio rocks out at 100.7 MHz (FM radio station frequencies are in megaHertz). Calculate the wavelength in meters for this Phoenix station.

4. Which travels faster – X rays or microwaves? Explain your answer.

5. Several Predators (aliens that “see” IR radiation) have landed near your house one dark night, and Arnold is nowhere to be found. Your filtered lamp is emitting radiation of \( 5.45 \times 10^{-19} \) J per photon of energy. If Predators can only sense IR radiation, will they see the radiation from your lamp? Calculate the frequency and wavelength of the lamp emissions and then look at Figure 3.1 in the book to determine if this radiation is in the IR range. Report the frequency, wavelength and type of radiation at the bottom of this page as indicated.

\[
\nu = \quad \text{Hz} \quad \lambda = \quad \text{nm} \quad \text{Type of radiation} \quad \text{___________}
\]