FLAME TEST

Adapted from Lab Manual for Chemistry in Your Life, 2nd ed., by Brian T. Arneson and Anna R. Bergstrom

Lab Overview

In this experiment you will determine the colors of the light emitted from substances that are thermally excited in the flame of a Bunsen burner.

The color of a chemical compound depends on the arrangement of its electrons (a.k.a. electron configuration). In this week's experiment you will study the color/light of several chemical species caused by emission. Emission takes place when electrons in an atom are excited by an external energy source, a process that results in a so-called **excited** atom. An important characteristic of excited atoms is the fact that they return to their initial state emitting light. This characteristic is readily observable in any fireworks display or neon signs. In each of these examples, excited atoms relax back to their original states, emitting light of various colors in the process. The color of the emitted light depends on the nature of the atom and its specific electronic configuration. Different atoms produce different colors, making the emitted light/color a fingerprint of the respective atom. This can assist us in identifying the atoms involved.

Before your lab section meets, please review Chapter 9 (Electrons in Atoms and the Periodic Table), specifically subchapters 9.3-9.5. There, you will read about light's components, called photons. A photon is an electromagnetic radiation with specific wavelengths. The specific wavelength of the electromagnetic radiation determines the color of the light that our eyes perceive. Visible light is a small portion of the electromagnetic spectrum (400-800 nm) located in between ultraviolet and infrared radiation.

Observed Color	Radiation Wavelength Range
Violet	**400–425 nm**
Blue	**440–460 nm**
Green	**475–520 nm**
Yellow	**525–575 nm**
Orange	**580–615 nm**
Red	**625–750 nm**

The light emitted from atoms comes from electronic transitions. As describe in Chapter 9 (Electrons in Atoms and the Periodic Table), electrons reside in shells located progressively farther away from the nucleus of the atom. Electrons in specific shells have specific energies, with electrons located in lower shells (closer to the nucleus) having lower energies as compared to electrons located in higher shells (farther away from the nucleus). An atom can be excited by an external energy source. The external energy causes an electron to gain energy and, because of this, the electron will have the energy to move from one shell to another shell located at a higher energy. However, this excitation is short-lived and the excited electron will eventually fall back to its original shell, releasing energy as a photon of electromagnetic radiation. The energy of the photon released is inversely related to the wavelength of the photon $E_{\text{photon}} \alpha \frac{1}{\lambda}$, where λ is wavelength of a photon. Given the inverse relationship, it follows that photons that have more energy have shorter wavelengths and, conversely, photons that have less energy have longer wavelengths. It is important to note that each element has a unique arrangement of its electrons. For example, when calcium atoms are excited, the excited electron falls from a higher energy shell to a lower one releasing light at a specific wavelength. All calcium atoms will emit light at this wavelength. Different elements will emit light at different wavelengths. Not all elements emit energy as **visible** light; some elements will only emit very short or long wavelength photons that the human eye cannot detect.

Experimental Part

Materials: Bunsen burner, matches, cotton swabs

Reagents: Approx. 10 mL of the following solutions: 1 M NaCl ; 1 M KI ; l M NaI; 1 M KCl ; 1 M $CaCl_2$; 1 M $CuSO_4$; 1 M $BaCl_2$; 1 M Borax. Note: 1M notation represents the molar concentration of solutions. 1 M = 1 mole solute/ (1 Liter of solution)

Caution! Always wear safety goggles while in the lab. Holding the swab over the flame may cause the stem of the cotton swab to melt. Do not hold the cotton swab over the flame for an extended period of time because the swab itself might ignite. Keep your hand away from the flame by holding the bottom of the cotton swab.

You will test the water solutions listed under Reagents. These solutions contain different metal salts. You will use a Bunsen burner flame to thermally excite the electrons of the ions present in solution. The excited electrons will fall back to their original state and in the process emit the excess energy. The energy is emitted as photons of electromagnetic radiation and if the energy has a wavelength between 400 nm and 750 nm, you will observe the energy released as visible light.

To perform the flame test, light a Bunsen burner and adjust the flame until it is nearly colorless. Then dip a cotton swab into your test solution and hold the cotton swab near the outside edge of the flame. As the solution evaporates, the metal salt will start to emit its characteristic color. ***Caution: Do not get your hand too close to the flame. If you do not see any color after a few minutes, try dipping the swab again in the solution.***

Experimental Procedure

1. Dip the end of a cotton swab into one of the eight solutions.

2. Hold the cotton swab next to the Bunsen burner flame so that the wet end just touches the flame.

3. After a few seconds, the characteristic color from the test solution will appear in the flame. Record the color of the flame.

4. Repeat for each of the given solutions.

5. Construct a data table; identify which element can be identified by its characteristic color.

Cleanup and Waste Disposal: Dispose of leftover solutions in the appropriate containers in your laboratory, as indicated by your TA.

Data Table and Observations

Solution #	Salt dissolved in solution	Color observed	Element responsible for color
1			
2			
3			
4			
5			
6			
7			
8			

Post Experiment Questions

1. What conclusions can you make about flame color and the elements in a solution?

2. Which elements are responsible for the different colors you observed?

3. If you saw a blue flame, would that have more energy than a yellow flame?

4. What color would you expect to see in a flame test for a solution made by combining sodium chloride and copper sulfate?

Post-Lab Quiz. Return to bblearn and complete your post-lab quiz.